ATTACHMENT D
S-480-79
REV. C

PERFORMANCE ASSURANCE REQUIREMENTS (PAR)

FOR THE EOS/METSAT INTEGRATED PROGRAMS

AMSU-A INSTRUMENT

REVISED DECEMBER 1999

GODDARD SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GREENBELT, MARYLAND

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PERFORMANCE ASSURANCE REQUIREMENTS FOR THE EOS & METSAT ADVANCED MICROWAVE SOUNDING UNITS - A

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This is a Project Office controlled document. Changes require prior approval of the Project Manager. Proposed changes shall be submitted to the Project Configuration Management Officer.

REVISION PAGE

Revision Letter	Contract Mod #	Date	CCR #	Date	Section(s) Revised
A	26	8/27/96	1378	12/18/95	Replaced entire section 5, revised 7.3.1, 8.12, repaginated pages 26-79; revised Appendix A 7; revised Appendix C 3.1, Table 3-1; revised Appendix D 3.6.3.1
A	26	8/27/96	1417	07/22/96	Table 3-1
B	47	5/04/98	1537	03/10/98	Appendix C 3.6.3, 3.6.3.1, 3.6.3.2, added Figures C1 and C2, repaginated pages C-15 thru C-24
C	74	12/08/99	8121	01/13/99	Deleted entire section 8.13.2.3

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SECTION 1

GENERAL REQUIREMENTS

1.1 BASIS AND SCOPE OF THE REQUIREMENTS

This document is an adaptation of the requirements of NASA reliability and quality assurance Handbooks NHB 5300.4 (1A, 1B and 1F).
It establishes common hardware and software product assurance minimum requirements with respect to safety, reliability, maintainability, and quality for all contractor's involved in the design, development, production, test and operation of instruments and their support equipment for the Earth Observing System (EOS), and The Meteorological Satellites (Metsat) Project. In addition, Appendix C (EOS), and Appendix D (Metsat) further define program unique elements which have been tailored to meet performance assurance requirements of each mission.

This document also defines expanded performance assurance requirements in areas of reviews, functional and environmental testing, contamination control, parts control, materials control, mission simulations and end-to-end operational testing. It also requires compliance with applicable parts of WRR 127-1, "Range Safety Requirements, Western Range.

1.2 GENERAL REQUIREMENTS

The contractor shall establish and conduct an organized program which will demonstrate that the instrument design meets the functional requirements, including specified margins, has been manufactured properly and will operate properly in association with all other project components. This will be accomplished by conducting analyses, reviews, tests, and inspections.

The contractor is required to implement and maintain a performance assurance program that encompasses flight equipment and software including flight spares and associated Government furnished flight equipment. The program applies to all work accomplished by the contractor and his subcontractor's and suppliers (also termed "contractor") who provide flight hardware and support.

1.3 USE OF PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

The contractor is required to demonstrate that the hardware proposed will comply with the requirements of this document as well as the performance requirements. When previously designed, fabricated, or flown hardware is proposed for use on this Project and is considered to have demonstrated compliance with the requirements of this document, the contractor shall submit documentation substantiating that conclusion.

The documents must provide the following information:

(a) Compare each performance, design, environmental, and interface requirement, including margins, for this Project (as delineated in other documents related to this procurement) with the corresponding previous requirement. For any mission requirement or environmental difference from the previous use, either describe the modifications to be made to the hardware and software to meet Metsat/EOS mission requirements, or provide a rationale and supporting information stating why use without modification is considered acceptable.

(b) Compare each performance assurance requirement for this Project (as delineated in this document) with the corresponding previous requirement. Also, identify all waivers and deviations from the performance assurance requirements accepted on the previous program. For any requirement of the previous program that does not comply with the requirements of this Project, or for any previous deviation or waiver, describe what will be done to achieve compliance or provide a rationale and supporting information stating why the difference is considered acceptable. In addition, state how any modifications proposed as a result of;

(a) Above, will be shown to comply with the performance assurance requirements of this document.

(b) Compare the manufacturing information for the hardware proposed for this Project with that for the previous hardware. This shall include as a minimum the name and location of the manufacturer, the date of manufacture, any design changes, any changes to parts or materials, any modification to packaging techniques, and any change to fabrication or assembly controls or processes.

(c) Describe all flight experience with the proposed hardware including, in particular, a description of all failures or anomalies, their cause, and any corrective action that was taken as a result.

The documentation described above shall be submitted to NASA in accordance with GSFC-422-12-12-04 (CDRL).

1.4 MANAGEMENT OF THE ASSURANCE PROGRAM

The contractor shall implement a system for effective management control and audit of the assurance program. He shall assign responsibility and authority for managing the assurance activities to individuals having unimpeded access to higher management. The contractor shall ensure that assurance personnel have timely unimpeded access to products in order to perform pertinent assurance functions and that these personnel participate as appropriate in test planning activities and review activities.

1.5 PERFORMANCE ASSURANCE STATUS REPORT

Each month a Performance Assurance Status Report shall be prepared that contains the status of the assurance activities and any deficiencies that could affect the end item product; the causes of the deficiencies and intended or actual corrective action shall be included. The report shall cover, as appropriate, the following items as well as those called for in the individual sections of this document:

a. Significant assurance problems,

b. Key organization and personnel changes,

c. Unresolved hazards (safety program),

d. Summary of significant analysis, inspection, and test activities, failure/anomaly resolution,

e. Status of procurements and subcontractor performance assurance programs,

f. Audit reports summaries of internal and subcontractor audits (see para. 1.9.2),

g. Summary reports of contractor reviews (see para. 2.5),

h. Results of Alerts and special problem surveys,

i. NSPAR Status,

j. Parts or devices procurement or screening activities.

k. Results of Trend Analyses,

l. Status Summaries of open Problem/Failure reports. (see para. 8.13.2.1b.).

The Performance Assurance Status Report shall be submitted to GSFC in accordance with GSFC-422-12-12-04 (CDRL).

1.6 SURVEILLANCE OF THE CONTRACTOR

The work activities, operations and documentation of the contractor, subcontractor's, and suppliers are subject to evaluation, review, survey, and inspection by government-designated representatives from the NASA project office, the cognizant Government Inspection Agency (GIA), or an Independent Assurance Contractor (IAC) at the contractor's facilities and at any other location. NASA will delegate comprehensive and specific in-plant responsibilities and
authority to those agencies in a Letter Of Delegation (LOD) or the NASA contract with the IAC.

The contractor shall provide the government representative with documents, records, equipment, and working areas within his facilities that are required by the government representative to perform his overview activities.

Where contractor source inspection is used, the contractor shall provide a list of duties, responsibilities, and authorities of his at-source quality assurance (QA) personnel to the designated Government quality representative at the contractor's facility. When both contractor and government source inspection personnel are used at any contractor's facility, the listing shall also be provided to the government source representative at that facility, upon issuance of the procurement. At no time shall government source inspection be used in lieu of contractor's source inspection.

1.7 GENERAL PROCUREMENT REQUIREMENTS

1.7.1 SELECTION OF SOURCES

When the contractor selects procurement sources, he shall assign assurance personnel to participate in the selection. Performance history, receiving inspection and test results, supplier rating system, and survey results shall be used to assess the capability of each potential procurement source in producing reliable products.

1.7.2 REQUIREMENTS ON SUBCONTRACTOR AND SUPPLIERS

The contractor shall ensure that his procurement documents impose the applicable requirements of this document on subcontractor's and other suppliers. The subcontractor and other suppliers shall in turn impose the requirements on their procurement sources.

1.8 AUDITS

The contractor shall conduct audits of his assurance activities and those of his subcontractor's and suppliers to ensure compliance with all provisions of the PAR and the provisions of the procurement document.

To verify the effectiveness of the performance assurance systems, each audit shall include examination of operations and documents as well as examination of articles and materials.

1.8.1 SUBCONTRACTORS AND SUPPLIER AUDITS

The contractor shall perform audits of his subcontractor's and suppliers as necessary to ensure compliance with the subcontractor performance assurance requirements.

The contractor's schedule and conduct of the audits shall be based on the following:

a. Criticality of items being procured, or those items identified by failure mode and effects analyses, or information from trend analyses,

b. Known problems or difficulties,

c. Supplier quality history,

d. Remaining period of supplier performance.

1.8.2 AUDIT REPORTS

A documented account of audits shall be provided to management of the audited organization with recommendations for correction of deficiencies. Management action shall be taken to ensure correction of the deficiencies, and reviews shall be conducted to ensure that the corrections have been made. Audit reports shall be made available to the Government representative upon request, and a summary of the audit reports shall be submitted to NASA as part of the Performance Assurance Status Report (par. 1.6).

1.9 APPLICABLE DOCUMENTS (APPENDIX A)

To the extent referenced herein, applicable portions of the documents listed in Appendix A, at the revision levels in effect at the time of issuance of the Request for Proposals, form a part of this document. Where any referenced document conflicts with the requirements of this document, this document will take precedence.

1.10 ABBREVIATIONS, ACRONYMS, and GLOSSARY (APPENDIX B)

Appendix B lists abbreviations, acronyms, and definitions that are needed for a common understanding of terms as applied in this document.

1.11 EOS UNIQUE REQUIREMENTS (APPENDIX C)

Appendix C defines tailored requirements that are specific to EOS developed hardware and software.

1.12 METSAT UNIQUE REQUIREMENTS (APPENDIX D)

Appendix D defines tailored requirements that are specific to Metsat developed hardware and software.

1.13 METSAT ENVIRONMENTAL SPECIFICATIONS (APPENDIX E)

Appendix E lists environmental specifications applicable to Metsat.

2.0 ASSURANCE REVIEW REQUIREMENTS

2.1 GENERAL REQUIREMENTS

The contractor shall support a series of comprehensive instrument-level and system-level design reviews that are conducted by a GSFC Flight Assurance Review Team. The reviews shall cover all aspects of flight and ground hardware, software and operations for which the contractor has responsibility. The contractor shall also conduct a program of planned, scheduled and documented contractor reviews (see par. 2.5) at component and subsystem levels of all hardware and software in his area of responsibility.

2.2 GSFC FLIGHT ASSURANCE REVIEW REQUIREMENTS

For each specified review conducted by a GSFC Flight Assurance Review Team, the contractor shall:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of visual aids and other supporting material that are pertinent to the review shall be submitted in accordance with GSFC-422-12-12-04 (CDRL).

b. Support splinter review meetings resulting from the major review.

c. Submit written responses to recommendations and action items resulting from the review.

2.3 GSFC FLIGHT ASSURANCE REVIEW PROGRAM

The Flight Assurance Review Program shall consist of individual reviews of the instruments and associated systems as follows: (Appendix C (EOS) and Appendix D (Metsat) contain mission specific review requirements).

a. Preliminary Design Review (PDR). This review shall be conducted at the conclusion of the detailed design efforts and after testing the breadboard models of critical designs. Topics to be reviewed will include designs, analyses, calibration techniques, and instrument certification test plans. (See Appendix D for additional Metsat requirements).

b. Critical Design Review (CDR). This review is conducted to buy off the "frozen" design prior to the start of manufacture of flight components. It will emphasize implementations of design as well as test plans for flight systems including the results of engineering model testing.

c. Pre-environmental Review (PER). This review occurs prior to the start of environmental testing of the (instrument) protoflight or flight system. The primary purposes of this review are to establish the readiness

of the system for test and to evaluate the environmental test plans.

d. Pre-shipment Review (PSR). This review will take place prior to delivery of the instrument to the Observatory for integration, and will concentrate on instrument performance during acceptance testing.

e. System Test Review (STR). EOS Only. See Appendix C, EOS Unique Requirements.

f. Mission Operations Review (MOR). EOS Only. See Appendix C, EOS Unique Requirements.

g. Flight Operations Review (FOR). EOS Only. See Appendix C, EOS Unique Requirements.

h. Flight Readiness Review (FRR). EOS Only. See Appendix C, EOS Unique Requirements.

2.4 SYSTEM SAFETY

System safety shall be an agenda item for each review in paragraph 2.3 and as such shall serve to support the total system safety review program specified in paragraph 4.7.

2.5 CONTRACTOR REVIEW REQUIREMENTS

The contractor shall conduct a program of reviews at the component and subsystem levels of the instrument. The program shall, as a minimum, consist of a PDR and a CDR at these levels of assembly. In addition, packaging reviews shall be conducted on all electrical, electronic, and electromechanical components in the instrument system.

The contractor shall also conduct design reviews of any custom designed microcircuits, including hybrids, as required by paragraph 5.2.2.4.

The PDR and CDR shall evaluate the ability of the component or subsystem concept and design to successfully perform its function under operating and environmental conditions during both testing and flight.

The packaging reviews shall be conducted in accordance with GSFC S-311-98A, "Guidelines for Conducting a Packaging Review" (see Appendix A). In addition to these packaging guidelines, the reviews shall specifically address the following:

a. Placement, mounting, and interconnection of each EEE part or circuit board or substrate.

b. Structural support and thermal accommodation of the boards and substrates and their interconnections in the component design.

c. Provisions for protection of the parts and ease of inspection

Component level CDR's and PDR's shall include report of the pertinent parts stress analyses required by paragraph 7.3.3 and reports of the associated tests and analyses.

Reviews shall be conducted by contractor personnel who are not directly responsible for hardware design. NASA reserves the right to attend the reviews and participate as reviewers and requires 20 working days notification. If so requested by the NASA Technical Officer, the contractor shall provide NASA a copy of the review input data package 15 working days in advance of the review. The results of the reviews shall be documented, and a summary of each review shall be included in the Performance Assurance Status Report in accordance with GSFC-422-12-12-04 (CDRL).
The review data shall be available to NASA upon request.

SECTION 3

PERFORMANCE VERIFICATION REQUIREMENTS

3.1 GENERAL REQUIREMENTS

A Performance Verification Program shall be conducted to ensure that the instrument meets the specified mission requirements. The program consists of a series of functional demonstrations, prototyping efforts, analytical investigations, calibration tests, physical property measurements, and environmental and performance tests that simulate the environments encountered during handling and transportation, prelaunch, launch, and in-orbit operations. All protoflight hardware shall undergo qualification to demonstrate compliance with the requirements of this section. All other flight hardware shall undergo acceptance verification in accordance with the requirements of this section unless specific modifications are permitted in a subparagraph entitled "Acceptance Requirements." The Performance Verification Program begins with functional testing of assemblies, continues through the functional and environmental testing, supported by appropriate analysis, at the component and instrument levels of assembly. See Appendix C (EOS) and Appendix D (Metsat) for additional Performance Verification Requirements.

3.1.1 SYSTEM SAFETY CONSIDERATIONS

Certain additional activities (not identified in this Section) that are needed to satisfy the safety requirements of Section 4 may best be accomplished during the Performance Verification Program. It is therefore required that the Performance and Safety Verification Programs be closely coordinated.

3.2 DOCUMENTATION REQUIREMENTS

The approach for accomplishing the Performance Verification Program shall be fully documented. This shall include a description of the management approach as well as the following plans, specifications, procedures, and reports, which are required to define the technical aspects of the Performance Verification Program.

3.2.1 VERIFICATION PLAN

A Verification Plan shall be prepared and maintained up-to-date that defines the tests and analyses that collectively demonstrate that the hardware complies with Sections 3.2 through 3.7 of this document. The Plan shall include all tests and analyses at the component, subsystem, and instrument level.

The Verification Plan shall provide an overview of the Verification Program and the overall approach to its accomplishment. For each test, it shall include the level of assembly, configuration of the item, objectives, facilities, instrumentation, safety

considerations, contamination control, test phases and profiles, necessary functional

operations, personnel responsibilities, and requirements for procedures and reports. It shall also define a rationale for retest
determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity shall be described. For each analysis activity, the plan shall include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports. The Verification Plan shall be delivered to NASA and updated in accordance with GSFC-422-12-12-04 (CDRL).

3.2.2 VERIFICATION SPECIFICATION

EOS Only. See Appendix C, EOS Unique Requirements.

3.2.3 VERIFICATION PROCEDURES

For each functional and environmental test activity conducted at the component, subsystem, and instrument level, verification procedures shall be prepared that describe in detail the configuration of the test article and how that particular test activity contained in the Verification Specification and Verification Plan will be implemented.

The procedures shall describe details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection, and reporting requirements. The procedures also shall address safety and contamination control provisions and measures to protect the hardware (e.g. connector savers). Procedures for calibrations and performance tests shall provide for real-time display of data in easily recognized engineering terms to the maximum extent practicable. Verification Procedures at the instrument level shall be submitted to GSFC in accordance with GSFC-422-12-12-04 (CDRL).

3.2.4 CONTROL OF UNSCHEDULED ACTIVITIES DURING VERIFICATION

A documented procedure shall provide for controlling, documenting, and approving all activities not part of an approved verification procedure or flight instrument calibration procedure. The contractor shall be alert to the hazard potential of last minute changes and shall institute controls at appropriate management levels to prevent accident, injury or hardware damage. Such control shall include appropriate real-time decision making mechanisms to expedite continuation (or suspension) of testing after a malfunction, with documented rationale. The control procedure shall be documented in accordance with GSFC-422-12-12-04 (CDRL), and in each Verification Procedure.

In the event of a failure during qualification testing or acceptance testing of a flight instrument, the contractor shall

stop the test and contact the Technical Officer (TO) or the TO's designated representative before proceeding. Normally, the complete test shall

be rerun, starting at the beginning of the test in which the failure occurred, unless the retest is shortened upon direction of GSFC.
The exact nature of retest will be determined by the TO.

3.2.5 VERIFICATION REPORTS

After completion of each instrument verification activity or flight instrument calibration, a report shall be submitted in accordance with GSFC-422-12-12-04 (CDRL). For each test activity, the report shall contain, as a minimum, the information described in the sample test report (see Figures 3-la and 3-lb). For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well the mathematical model was validated by the test data, and other significant results. Detailed test and analysis data supporting the verification reports shall be retained by the contractor; this data, as well as the as-run verification procedures, shall be available for review at the contractor's facility upon request.

3.3 ELECTRICAL FUNCTION TEST REQUIREMENTS

3.3.1 ELECTRICAL INTERFACE TESTS

Before the integration of an assembly, component, or subsystem into the next higher hardware assembly, electrical interface tests shall be performed to verify that all interface signals are within acceptable limits of applicable performance specifications.

During integration, the electrical harnessing shall be tested to verify proper routing of electrical signals. All such testing, as well as the accompanying integration activities, shall be performed in an area that conforms to the cleanliness criteria developed in response to Section 9.

3.3.2 PERFORMANCE TESTS

3.3.2.1 Comprehensive Performance Tests (CPT's). A CPT shall be conducted on the instrument and each component and subsystem upon completion of integration of all assemblies. When environmental testing is performed at a given level of assembly, additional CPT's shall be conducted during the hot and cold extremes of the temperature or thermal-vacuum test and at the conclusion of the environmental test sequence, as well as at other times prescribed in the Verification Specification. The CPT shall be a detailed demonstration that the hardware meets its performance requirements within allowable tolerances.

PERFORMANCE VERIFICATION

DOCUMENTATION
Page___of___

VERIFICATION TEST REPORT

PROJECT _____

TEST ITEM _____

MANUFACTURER _____

SERIAL NUMBER _____

LEVEL OF ASSEMBLY: ☐ COMPONENT ☐ SUBSYSTEM ☐ PAYLOAD

TYPE HARDWARE: ☐ PROTOTYPE ☐ PROTOFLIGHT ☐ FLIGHT ☐ SPARE

TYPE TEST:

- ☐ STRUCTURAL LOADS
- ☐ VIBRATION
- ☐ ACOUSTICS
- ☐ MECHANICAL SHOCK
- ☐ MECHANICAL FUNCTION
- ☐ MODAL SURVEY
- ☐ PRESSURE PROFILE
- ☐ MASS PROPERTIES
- ☐ ELECTROMAGNETIC COMPATIBILITY
- ☐ MAGNETIC PROPERTIES
- ☐ THERMAL - VACU
- ☐ THERMAL BALANC
- ☐ THERMAL CYCLIN
- ☐ TEMPERATURE - HUMIDITY
- ☐ LEAKAGE
- ☐ COMPREHENSIVE PERFORMANCE
- ☐ OTHER (explain) _____

VERIFICATION PROCEDURE NO. _____ REV. _____ DATE _____

☐ INITIAL TEST

☐ RETEST (☐ PARTIAL OR ☐ FULL; STARTING DATE OF INITIAL TEST_____)

APPLICABLE VERIFICATION PLAN: _____

FACILITY DESCRIPTION: _____

LOCATION: _____

TEST LOG REFERENCE: _____

COMMENTS:

SIGNATURE:

QUALITY ASSURANCE REPRESENTATIVE: _____ DATE _____

COGNIZANT ENGINEER FOR TEST ITEM: _____ DATE _____

Figure 3-1a Verification Test Report

PERFORMANCE VERIFICATION

DOCUMENTATION

VERIFICATION TEST REPORT (Continued)

Page___of___

Date (add time for thermal and temperature tests)	Note beginning and end of actual activity, deviations from the planned procedure, and discrepancies in test times performance. (State if there were no deviations or discrepancies.)	Malfunction Report Number and Date (if applicable)
	(use additional paper as required)	

The activities covered by these reports include tests and measurements performed for the purpose of verifying the flightworthiness of hardware at the component, subsystem, and payload levels of assembly. These reports shall also be provided for such other activities as the project may designate.

These reports shall be completed and transmitted to the GSFC Technical Officer or Contracting Officer (as appropriate) within 30 days after the completion of an activity. Legible, reproducible, handwritten completed forms are acceptable.

Material felt necessary to clarify this report may be attached. However, in general, test logs and data should be retained by those responsible for the test unless they are specifically requested.

The forms shall be signed by the quality assurance representative and the person responsible for the test item or his designated representative; the signatures indicate concurrence that the data is as accurate as possible given the constraints of time imposed by quick-response reporting.

This report does not replace the need for maintaining complete logs, records, etc.; it is intended to document the implementation of the verification program and to provide a minimum amount of information as to the performance of the test item.

Figure 3-1b Verification Test Report (Continued)

The test shall demonstrate operation of all redundant circuitry. It shall also demonstrate satisfactory performance in all operational modes within practical limits of cost, schedule, and environmental simulation capabilities. The initial CPT shall serve as a baseline against which the results of all later CPTs can be readily compared.

At the instrument level, the CPT shall demonstrate that, with the application of known stimuli, the instrument will produce the expected responses. At lower levels of assembly, the test shall demonstrate that, when provided with appropriate stimuli, internal performance is satisfactory and outputs are within acceptable limits.

3.3.2.2 Limited Performance Tests. Limited performance tests shall be conducted before, during, and after environmental tests, as appropriate, in order to demonstrate that functional capability has not been degraded by the environmental tests. Limited performance tests are also used in cases where a CPT is not warranted or not practicable. Specific times at which limited performance tests will be conducted shall be prescribed in the Verification Specification. Limited performance tests shall demonstrate that the performance of selected functions is within acceptable limits.

3.3.2.3 Limited Life Electrical Elements. A life test program shall be considered for electrical elements that have limited lifetimes. The Verification Plan shall address the life test program, identifying the electrical elements that require such testing, describing the test hardware that will be used, and the test methods that will be employed. Limited life electrical items shall be included in the Limited Life List as required in Section 7 of this document.

3.3.2.4 Trouble Free Performance Testing. At the conclusion of the performance verification program, instruments shall have demonstrated minimum reliability acceptability by trouble-free performance testing for at least the last 100 hours of (combined) testing prior to launch. Trouble-free operation during the thermal vacuum test exposure and during testing of the integrated spacecraft may be included as part of the demonstration. Major hardware changes during or after the verification program shall invalidate previous demonstration.

3.4 STRUCTURAL AND MECHANICAL REQUIREMENTS

3.4.1 GENERAL REQUIREMENTS

The contractor shall demonstrate compliance with structural and mechanical requirements with a series of interdependent test and analysis activities. (Appendix C (EOS) and Appendix D (Metsat) contain mission specific Structural and Mechanical Requirements).

3.4.2 REQUIREMENTS SUMMARY

When planning the tests and analyses, the contractor shall consider all expected environments including those of structural loads, vibroacoustics, sine vibration, mechanical shock, and pressure profiles. Mass properties and mechanical functioning shall also be verified. See Appendix C (EOS) and Appendix D (Metsat) for mission unique requirements.

3.4.3 STRUCTURAL LOADS

3.4.3.1 Verification for Design Qualification. Verification for the structural loads environment shall be accomplished by a combination of test and analysis. See Appendix C (EOS) and Appendix D (Metsat) for mission unique requirements.

3.4.4 VIBROACOUSTICS

See Appendix C (EOS) and Appendix D (Metsat) for mission unique requirements.

3.4.6 MECHANICAL FUNCTION

See Appendix C (EOS) and Appendix D (Metsat) for mission unique requirements.

3.4.6.1 Life Testing. Mechanical elements that move repetitively in their normal function shall be identified and verified for adequate useful life expectancy for the mission. They shall be included in the Limited-Life List as required in Section 7 of this document. Life testing methods and hardware to be used shall be described in the Verification Plan and Specification. Verification of useful lifetime by analysis shall require a description of rationale (for not testing) and supporting analyses for each element that is not tested.

3.4.7 PRESSURE PROFILE

3.4.7.1 Verification for Design Qualification. The need for a pressure profile test shall be assessed for all instruments and components. A verification test shall be performed if analysis does not indicate a positive margin at loads equal to twice those induced by the maximum expected pressure differential during launch. If a test is required, the limit pressure profile is determined by the predicted pressure-time profile for the nominal trajectory of the particular mission. Because pressure-induced loads vary with the square of the rate of change, the verification pressure profile is determined by multiplying the predicted pressure rate of change by a factor of 1.12 (the square root of 1.25, the required verification factor on load).

3.4.7.2 Acceptance Requirements. Pressure profile test requirements do not apply for the acceptance testing of previously qualified hardware.

3.4.8 MASS PROPERTIES

Hardware mass property requirements for the instruments are stated in the instrument UIIS and/or ICD. The contractor's mass properties program must include an analytic assessment of the instrument's ability to comply with the mission requirements, supplemented as necessary by measurement.

3.4.9 SINE VIBRATION

EOS Only. See Appendix C, EOS unique requirements.

3.5 ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

3.5.1 GENERAL REQUIREMENTS

The general requirements for electromagnetic compatibility are stated below:

a. The instrument and its components shall not generate electromagnetic interference that could adversely affect its own elements, other payload instruments, the spacecraft or the safety and operation of the launch vehicle.

b. The instrument and its components shall not be susceptible to emissions that could adversely affect their safety and performance. This applies whether the emissions are self-generated or derive from other sources, or whether they are intentional or unintentional. The requirements in this document include an assurance that the instrument can operate satisfactorily within the environments usually encountered during integration and ground testing. However, some instruments may have particularly sensitive sensors and electrical devices that are inherently susceptible to the EMI that may be expected in these ground environments; in such cases, special workaround procedures must be developed to meet individual instrument needs.

3.5.2 REQUIREMENTS SUMMARY

3.5.2.1 The Range of Requirements. See Appendix C (EOS) and Appendix D (Metsat) for mission unique requirements.

3.5.2.2 Basis of the Tests. EOS Only. See Appendix C, EOS Unique Requirements.

3.6 VACUUM, THERMAL, AND HUMIDITY REQUIREMENTS

3.6.1 GENERAL REQUIREMENTS

The following instrument (or instrument equipment) capabilities shall be demonstrated to satisfy requirements in the vacuum, thermal, and humidity areas:

a. The instrument shall perform satisfactorily in the vacuum and thermal environment of space.

b. The thermal design and the thermal control system shall maintain the affected hardware within the established mission thermal limits.

c. The hardware shall withstand, as necessary, the temperature and humidity conditions of fabrication, assembly, transportation, and storage.

3.6.2 SUMMARY OF REQUIREMENTS

EOS Only. See Appendix C, EOS Unique Requirements.

3.6.3 THERMAL-VACUUM

See Appendix C (EOS) and Appendix D (Metsat) Mission Unique Requirements.

3.6.4 THERMAL BALANCE

3.6.4.1 Verification for Design Qualification. This verification shall demonstrate the validity of the thermal design and the ability of the thermal control system to maintain the instrument within the established thermal limits for the mission. The analytical thermal model shall be validated by tests conducted on a (hardware) thermal model or the flight instrument. The capability of the thermal control system shall be demonstrated in the same manner. If the flight instrument is not used in the test of the control system, verification of critical thermal properties (such as those of the thermal control coatings) shall be performed to demonstrate similarity between the item tested and the flight instrument. Although it is desirable to perform the test on a complete instrument it may be impracticable to do so; therefore, the demonstration may be accomplished by combining test and analysis.

3.6.4.2 Acceptance Requirements. The thermal balance verification may be waived in the case of previously qualified hardware if there is valid similarity between the new and original applications. Analyses/tests shall be conducted to verify the thermal similarity to the qualified hardware.

3.6.5 TEMPERATURE-HUMIDITY: INTEGRATION, CHECKOUT, TRANSPORTATION AND STORAGE

3.6.5.1 Verification for Design Qualification. Analysis and, when necessary, test shall demonstrate that flight hardware that is not maintained in a controlled temperature-humidity environment to within demonstrated acceptable limits will perform satisfactorily after exposure to the uncontrolled environment.

The test shall include exposure of the hardware to the extremes of temperatures and humidities as follows: l0 degrees C and l0 percent RH (but not greater than 95 percent RH) higher and lower than those predicted for the transportation and storage environments. The exposure at each extreme shall be for a period of 6 hours.

3.6.5.2 Acceptance Requirements. The l0 degrees C temperature margin and the l0 percent RH margin may be waived for previously qualified hardware.

3.6.6 LEAKAGE

This test shall demonstrate that leakage rates of sealed instrument hardware are within the prescribed mission limits. Leakage rates shall be checked before and after stress-inducing portions of the verification program to disclose anomalies caused by that portion. The final check may be conducted during the final thermal-vacuum test. Checks at the instrument level need include only those items that have not demonstrated satisfactory performance at the component level or are not fully assembled until the higher levels of integration.

3.7 END-TO-END TEST REQUIREMENTS

EOS Only. See Appendix C, EOS Unique Requirements.

3.7.1 COMPATIBILITY TEST

EOS Only. See Appendix C, EOS Unique Requirements.

3.7.2 MISSION SIMULATIONS

EOS only. See Appendix C, EOS Unique Requirements.

4.0 SYSTEM SAFETY REQUIREMENTS

4.1 GENERAL REQUIREMENTS

The contractor shall plan and conduct a system safety program for the instrument and contractor supplied ground support equipment (GSE) that accomplishes the following:

a. Provides for the identification and control of hazards to personnel, facilities, support equipment, and flight systems during all stages of project development and integration. The program shall also consider hazards in the flight hardware, software, and associated equipment and potential malfunctions in instrument GSE that may affect the spacecraft or the launch vehicle.

b. Satisfies the applicable guidelines, constraints, and requirements stated in the revisions of the following documents current at time of Contract Award:

(1) Western Range Regulation WRR 127-1, Range Safety Requirements

(2) MIL-STD-882C, System Safety Program Requirements (to the extent specified in this PAR)

c. Interfaces effectively with the industrial safety requirements of the contract and the contractor's existing safety program.

d. Meets flammability requirements stated in par. 4.10, herein.

4.2 SYSTEM SAFETY IMPLEMENTATION PLAN (SSIP)

The contractor shall prepare and submit a System Safety Implementation Plan (SSIP) that constitutes Section 4 of the PAR.

The SSIP shall describe the safety program requirements, the plan for implementing them, and shall reference the detailed procedures the contractor will invoke to ensure the identification and control of hazards to personnel and hardware during fabrication, tests, transportation, ground activities, launch, and mission operations.

The plan shall address the following areas: system safety organization, interfaces, and responsibilities; system safety methodologies; internal and external safety review process; launch site safety; verification and operating procedures; hazardous operation surveillance; accident investigation and reporting; operator training and certification; safety audits; monitoring of subcontractor's; documentation to be provided; milestone schedule of all major system safety activities which shows their time phasing with other related major activities; procedure for

reporting problems and

activity status; and the industrial safety program responsibilities, functions, and interfaces with the system safety program.

4.3 STRUCTURAL INTEGRITY AND FRACTURE CONTROL

Verification of the structural integrity of the instrument is required (see par. 3.4.3). When protoflight testing to verify the structural design is conducted, no further verification of fracture control is required. Where such testing is not required, or for follow-on hardware (which is not normally subjected to protoflight testing), the contractor shall verify structural integrity by subjecting the instrument hardware to an appropriate series of proof loads tests to limit levels.

4.4 ANALYSES

4.4.1 HAZARD ANALYSES

Early in the design phase the contractor shall perform hazard analyses to identify any potential hazard(s) originating from the instrument or contractor provided GSE. The analyses shall be performed at the component and instrument levels and shall identify all hazards affecting personnel, ELV hardware, the spacecraft, spacecraft GSE, instrument GSE, other payload instruments, or the contractor's instrument. The analyses shall be oriented to the requirements/hazards areas identified in Chapters 3 and 5 of WRR 127-1 and shall provide all information necessary to complete the hazard identification and elimination/control requirements of the "Safety Assessment Report" (SAR) as applicable to the instrument. A separate
Payload Hazard Report (Figs. 4-1 & 4-2) shall be generated for each specific hazard identified. The hazard report shall document the causes, controls, verification methods, and status of verification for each hazard.

Throughout the instrument development effort, the contractor shall take measures to eliminate or to minimize the effects of each hazard identified. The hazard analysis and reports shall be updated as the hardware progresses through the stages of design, fabrication, test, transportation, integration, and launch. The hazard analyses shall be available at the contractors facility in accordance with GSFC-422-12-12-04 (CDRL). The Payload Hazard Reports shall be submitted as an included part of the Safety Assessment Report (SAR) (see section 4.9). The Payload Hazard Reports shall reflect status at the phase of the safety review program for which the current SAR is being submitted. Summaries of the Payload hazard reports and the status of hazard control efforts shall be reported at design and readiness reviews (see section 4.7).

4.4.2 OPERATIONS HAZARD ANALYSES

When the use of a facility or when the performance of an activity could result in subjecting the instrument or personnel to hazards, an Operations Hazard Analysis (OHA) shall be performed to identify the hazards and document the requirements for either eliminating or adequately controlling each hazard. Operations that may require analyses include handling, transportation, functional tests, and environmental test. A report of each OHA performed shall be submitted in accordance with GSFC-422-12-12-04 (CDRL).

4.5 HAZARD CONTROL VERIFICATION

Verification of the control of all hazards shall be accomplished by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities. Reports of such verifications performed by the contractor shall be incorporated in the Payload Hazard Reports (see section 4.4.1).

4.6 PROCEDURE APPROVAL

The contractor's safety engineer shall review and approve all procedures affecting flight hardware and contractor provided GSE for conformance with the SSIP. Hazardous operations shall be identified and procedures to control them shall be developed and implemented.

4.7 REVIEWS

The systems safety status shall be examined at the GSFC Flight Assurance Reviews as well as at other applicable Air Force Space Command Western Range (WR) safety reviews. The contractor shall submit the current safety data at the time of the GSFC PDR, CDR, PSR and all flight readiness reviews (See par. 2.3), as well as the WR phased safety reviews. The WR reviews are required as described in sections 3.3.3, 3.3.4, and 3.3.5 of WRR 127-1 at the following instrument milestones:

Phase 0 - Around the time of GSFC SCR

Phase 1 - Around the time of GSFC PDR

Phase 2 - Around the time of GSFC CDR

Phase 3 - 90 days prior to shipping the instrument to the spacecraft contractor.

The contractor shall provide data inputs required by the WR and technical support to the NASA project office for all safety reviews. The contractor shall review the systems safety program of subcontractor's.

4.8 DEVIATION/WAIVER

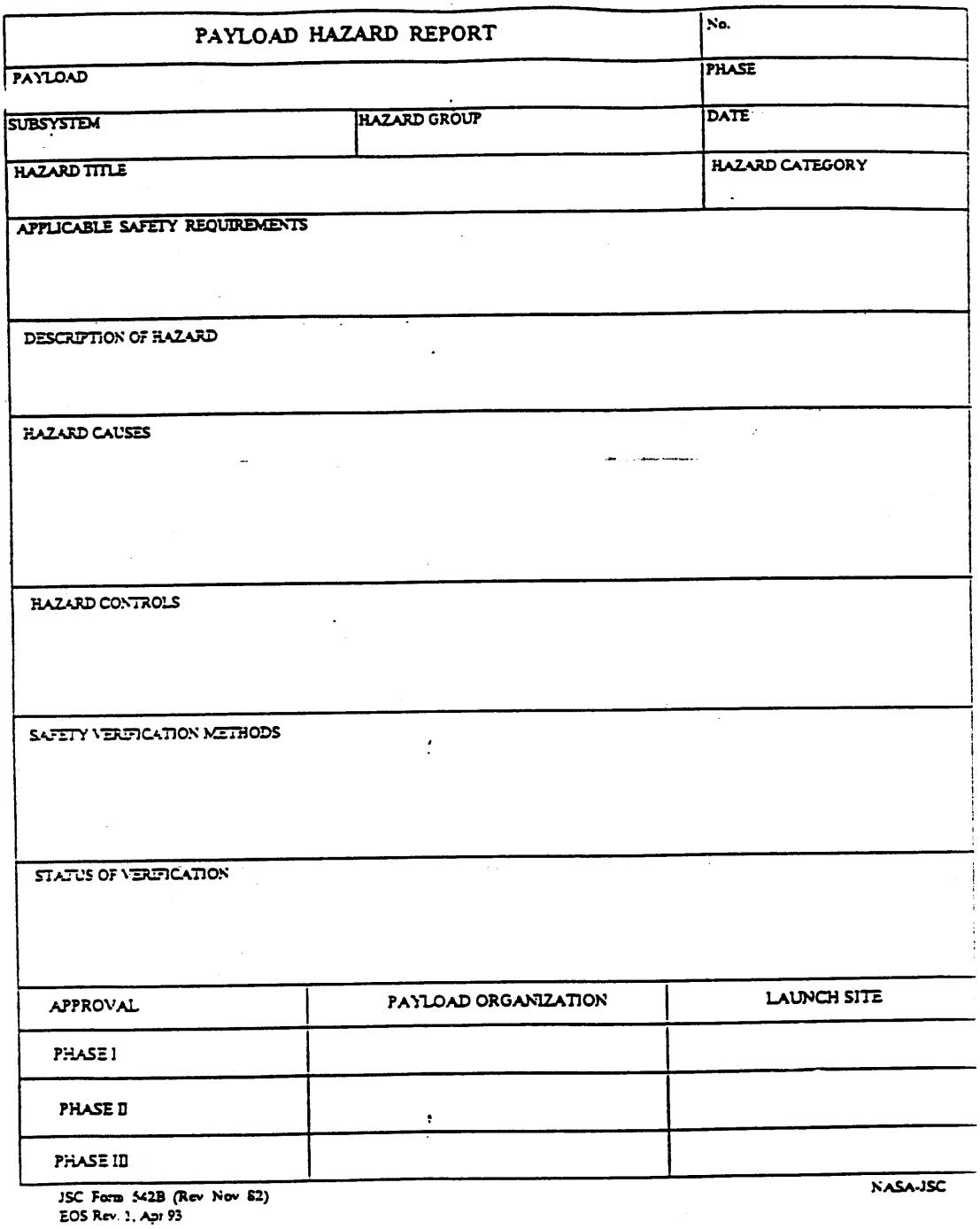
When a specific safety requirement can not be met, the contractor shall submit a deviation/waiver request (DOD Form 1694, see Figure 4-3). The waiver request shall state the requirement that cannot be met, the reason it cannot be met, the proposed method of controlling the additional risk, and the residual risk after application of the additional controls. Each deviation/waiver request
shall address only one hazard and shall be submitted in accordance with GSFC-422-12-12-04 (CDRL) as soon as it is determined that one is required. WRR 127-1 requires that each phased safety review consider any deviation/waiver requests that may have been generated.

4.9 SAFETY ASSESSMENT REPORT (SAR)

The contractor shall submit to NASA a Safety Assessment Report relative to the instrument which complies with the requirements of section 3.2.2 of WRR 127-1 (see par. 4.4.1, herein), and MIL-STD-882 Data Item Description DI-SAFT-80102 for an SAR prior to each of the WR phased safety reviews (see section 4.7 herein). The content of the package shall be appropriate to the phase of the program at the time of delivery and shall include the Payload Hazard Reports (see sections 4.4.1 and 4.5). The contractor shall include with the SAR copies of any pertinent deviation/waiver requests that have been generated (see section 4.7, above) and shall update the SAR as necessary. The data package shall be submitted to NASA in accordance with GSFC-422-12-12-04 (CDRL).

4.10 FLAMMABILITY

Flammability hazards shall be minimized in the selection and application of materials in the design. Wherever possible, materials shall conform with the flammability requirements of section 2.1.2 of NHB 8060.1 and other applicable NHB 8060.1 requirements. Where any flammable materials must be used, the following hazard elimination and control requirements apply: (a) two failure tolerance on ignition sources, (b) physical separation of the flammable material from ignition sources, and (c) elimination of flame propagation paths.



PAYLOAD HAZARD REPORT		No.
PAYLOAD		PHASE
SUBSYSTEM	HAZARD GROUP	DATE
HAZARD TITLE		HAZARD CATEGORY
APPLICABLE SAFETY REQUIREMENTS		
DESCRIPTION OF HAZARD		
HAZARD CAUSES		
HAZARD CONTROLS		
SAFETY VERIFICATION METHODS		
STATUS OF VERIFICATION		

APPROVAL	PAYLOAD ORGANIZATION	LAUNCH SITE
PHASE I		
PHASE II		
PHASE III		

JSC Form 542B (Rev Nov 82)
EOS Rev. 1, Apr 93

NASA-JSC

Figure 4-1 Payload Hazard Report

PAYLOAD HAZARD REPORT CONTINUATION SHEET	No.
Payload	Phase

Figure 4-2 Payload Hazard Report Continuation Sheet

DOD-STD-480A
12 April 1978

REQUEST FOR DEVIATION/WAIVER
(SEE MIL-STD-480 OR 481 FOR INSTRUCTIONS)

DATE PREPARED

PROCURING ACTIVITY NO.

1. ORIGINATOR NAME AND ADDRESS

2. ☐ DEVIATION ☐ WAIVER

3. ☐ MINOR ☐ MAJOR ☐ CRITICAL

4. DESIGNATION FOR DEVIATION/WAIVER				5. BASE LINE AFFECTED			6. OTHER SYSTEMS/CONFIGURATION ITEMS AFFECTED
a. MODEL/TYPE	b. MFR. CODE	c. SYS. DESIG.	d. DEVIATION NO.	☐ FUNCTIONAL	☐ ALLOCATED	☐ PRODUCT	☐ YES ☐ NO

7. SPECIFICATIONS AFFECTED-TEST PLAN				8. DRAWINGS AFFECTED			
	MFR. CODE	SPEC./DOC. NO.	SCN	MFR. CODE	NUMBER	REV.	MOD. NO.
a. SYSTEM							
b. ITEM							
c. TEST PLAN							

9. TITLE OF DEVIATION/WAIVER

10. CONTRACT NO. & LINE ITEM

11. CONFIGURATION ITEM NOMENCLATURE

CLASSIFICATION OF EFFECT

12. CO NO. | 13. DEFECT NO. | 14. DEFECT CLASSIFICATION ☐ MINOR ☐ MAJOR ☐ CRITICAL

15. NAME OF PART OR LOWEST ASSEMBLY AFFECTED | 16. PART NO. OR TYPE DESIG. | 17. LOT NO. | 18. QTY | 19. RECURRING DEVIATION/WAIVER ☐ YES ☐ NO

20. EFFECT ON COST/PRICE

21. EFFECT ON DELIVERY SCHEDULE

22. EFFECT ON INTEGRATED LOGISTIC SUPPORT, INTERFACE, ETC.

23. DESCRIPTION OF DEVIATION/WAIVER

24. NEED FOR DEVIATION/WAIVER

25. PRODUCTION EFFECTIVITY BY SERIAL NUMBER

26. SUBMITTING ACTIVITY AUTHORIZING SIGNATURE | TITLE

27. APPROVAL/DISAPPROVAL

a. ☐ APPROVAL RECOMMENDED

b. ☐ APPROVED ☐ DISAPPROVED

c. GOVERNMENT ACTIVITY | SIGNATURE | DATE

DD FORM 1694

Figure 4-3 DOD Form 1694 (DOD-STD-480)
Request for Deviation or Waiver.

SECTION 5 (Mod 25)

EEE PARTS CONTROL REQUIREMENTS

5.1 GENERAL REQUIREMENTS

The contractor shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program in accordance with the requirements of a Grade 1 quality level as set forth in this section. To assure clear understanding and proper implementation of the parts control program, the contractor shall prepare and submit a Parts Control Plan (PCP) to GSFC for review and approval in accordance with the contract schedule. The PCP shall detail the contractor's approach to meeting the requirements set forth in this section, and shall include such information as organization, functions, responsibilities, process flows, Parts Control Board (PCB) procedures, part approval criteria, methods for parts tracking and status, and documentation requirements. In lieu of generating a new PCP for this program, an existing contractor in-house PCP may be used provided that it addresses all of the requirements specified herein.

5.2 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL PARTS

All parts commodities identified in the GSFC Preferred Parts List (PPL) are considered EEE parts and shall be subjected to the requirements set forth in this section. Advanced technology devices such as Application Specific Integrated Circuits (ASIC), Multi-Chip Modules (MCM), High Density Interconnects (HDI), and Charge Coupled Devices (CCD) shall also be subject to parts control appropriate for the individual technology (see 5.2.7).

5.2.1 PARTS REQUIREMENTS

All parts selected for use in space flight hardware shall meet the requirements specified in the GSFC Instruction No. 311-INST-001 Instructions for EEE Parts Selection, Screening and Qualification. This document details parts selection and processing requirements and acceptance criteria for each part commodity and quality levels. The requirements applicable to this contract shall be those designated for a Grade 1 quality level, and as specified herein. The contractor shall document any exceptions to 311-INST-001 in the submitted PCP.

5.2.2 PARTS CONTROL BOARD

The contractor shall establish a Parts Control Board (PCB) to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. PCB operating procedures, to include such items as organizational chart, key personnel, schedules, minutes, etc., shall be made a part of the PCP (see 5.1). The PCB shall be chaired by the contractor's parts program manager or his designated representative. The PCB shall be responsible for the development

and maintenance of a Program Approved Parts List (PAPL) (see 5.2.3). In addition, the PCB shall be

responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. Meeting minutes shall be maintained by the contractor and a copy provided to GSFC within three days of convening the meeting.

GSFC participation at PCB meetings is not required. However, GSFC shall be notified in advance of upcoming meetings and shall be invited to participate in all PCB meetings. To assure effective and efficient PCB meetings, meeting notices shall include a list of parts to be reviewed. GSFC shall have voting rights at the meetings, and shall reserve the right to reverse any decisions of the PCB within 10 days after receipt of the PCB meeting minutes. PCB activities may be audited by GSFC on a periodic basis to assess conformance to the contractor's PCP.

5.2.3 PROGRAM APPROVED PARTS LIST

The contractor shall create and maintain a PAPL for the duration of the program. The PAPL shall be the only source of approved parts for flight hardware. Only parts that have been evaluated and approved by the PCB shall be listed in the PAPL. Parts must be approved for listing on the PAPL before initiation of procurement activity. The criteria for PAPL listing shall be based on 311-INST-001 and as specified herein (see 5.2.1). The PCB shall assure standardization and the maximum use of parts listed in the PAPL. The PAPL and all subsequent revisions shall be available for GSFC review upon request.

5.2.3.1 Initial PAPL. Parts designated as Grade 1 selected from the GSFC Preferred Parts List (PPL) or MIL-STD-975 NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List (NSPL) are considered to have met all applicable requirements specified in 311-INST-001 for a Grade 1 quality level and are approved for listing on the PAPL. The PCB shall ensure that these parts meet all mission and application requirements (such as derating and radiation requirements) before use in hardware design. All application notes or additional testing listed in the PPL and MIL-STD-975 shall apply. The PPL shall take precedence whenever differences in requirements exist between the PPL and MIL-STD-975. Parts shall be procured in accordance with the specification designated for the part.

5.2.3.2 Additions to PAPL. Parts not listed on the PAPL shall be submitted to the PCB for evaluation and approval before procurement. The contractor shall detail in the PCP the procedures for submission of requests for approval to the PCB, including the review and approval process. The request documentation should include justification for use of the requested part and any supporting data. Once the request has been approved by the PCB, the part may be added to the PAPL. The contractor shall document all review decisions in the meeting minutes.

5.2.3.3 Parts Approved on Prior Programs. Parts previously approved by the METSAT Project via a Nonstandard Parts Approval

Request (NSPAR) on the preceeding contract for the AMSU-A instrument shall be evaluated by the PCB for continued compliance to current program requirements prior to listing in the PAPL. This shall be accomplished by determining that:

a. No changes have been made to the previously approved NSPAR, Source Control Drawing (SCD) or vendor list.

b. All stipulations cited in the previous NSPAR approval have been implemented, including performance of any additional testing required on the current flight lot.

5.2.4 PARTS SPECIFICATION

All parts shall be procured in accordance with military, NASA, or contractor controlled specifications as specified in 311-INST-001. Specifications shall as a minimum contain the requirements specified in 311-INST-001 for a Grade 1 quality level.

5.2.5 PARTS QUALIFICATION

All parts shall be qualified in accordance with the qualification requirements specified in 311-INST-001, Grade 1, for each appropriate commodity.

5.2.6 PARTS SCREENING

All parts shall be screened in accordance with the screening requirements specified in 311-INST-001, Grade 1, for each appropriate commodity. Screening shall be performed on 100 percent of the parts in the procured lot.

5.2.7 HYBRIDS, MCM, ASIC, AND OTHER ADVANCED MICROCIRCUITS

Hybrids, MCM, ASIC, and other advanced microcircuits shall be designed and procured in accordance with the requirements of MIL-H-38534, General Specification for Hybrid Microcircuits, or MIL-I-38535, General Specification for Microcircuits, as applicable. Device class shall be B, S, Q, V, H, K, or equivalent. For parts not procured to a Qualified Products List (QPL) or Qualified Manufacturers List (QML), the contractor shall demonstrate that all requirements of MIL-H-38534, MIL-I-38535, and 311-INST-001 for microcircuits and hybrid microcircuits, as applicable, are met. The Project Parts Engineer should be consulted for assistance in this respect.

5.2.7.1 Custom Devices. Any custom microcircuits, hybrid microcircuits, ASIC, etc., planned for use by the contractor shall be subjected to a design review. GSFC shall be notified sufficiently in advance in order to participate in the review. The review may be conducted as part of the PCB activity, provided appropriate contractor and GSFC technical representatives are present. The design review shall address, at a minimum, derating of elements, method used to assure each element is of the appropriate quality level, and method for assuring adequate thermal matching of materials.

5.2.8 DERATING

All EEE parts shall be used in accordance with the derating guidelines of the PPL. The contractor’s derating policy may be used in place of

the PPL guidelines if it has received GSFC approval prior to use. A part stress analysis shall be performed for all applications and shall be available for GSFC review upon request.

5.2.9 RADIATION HARDNESS

All EEE parts shall be selected to meet their mission application in the predicted radiation environment. The contractor shall describe their plans for part radiation hardness assessment in the PCP. The radiation environment consists of two separate effects, those of total ionizing dose and single event upsets. The contractor shall document the analysis for each part with respect to both effects. Analysis for total ionizing dose shall include a design margin of 2X for EEE parts selected for flight applications.

5.2.10 DESTRUCTIVE PHYSICAL ANALYSIS

A Destructive Physical Analysis (DPA) shall be performed on a sample of each lot date code of hybrid microcircuits, microcircuits, semiconductors, ceramic capacitors, relays and crystal oscillators. DPA test, procedures, sample size and criteria shall be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. Any defects, as defined in S-311-M-70, seen in any samples shall be cause for rejection of the lot. Contractor's procedures for DPA may be used in place of S-311-M-70 if they have received GSFC approval prior to use. Variation to the DPA sample size requirements, due to part complexity, availability or cost, shall be determined and approved by the PCB on a case-by-case basis.

5.2.11 PARTS AGE CONTROL

Parts drawn from controlled storage after 5 years from the date of the last full screen shall be subjected to a full rescreen and sample DPA. Reduced testing such as Performance Verification Testing (PVT) or sample screen may be performed instead, as determined by the PCB, if it is deemed adequate for the particular part type. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination shall not be used. Existing contractor's parts age control plan, if available, shall be included as part of the PCP.

5.3 PARTS IDENTIFICATION LIST

A EEE Parts Identification List (PIL) shall be prepared, maintained, and updated by the contractor and submitted to GSFC in accordance with the contract schedule. All submissions to GSFC shall include a paper copy and a computer-readable form (tape or disk).

As opposed to the PAPL, the PIL shall list all parts planned for use in flight hardware, regardless of their approval status. The PIL shall be compiled by instrument, instrument component, or spacecraft component, and shall include the following information:

part name; part number; manufacturer; manufacturer’s generic part number; procurement specification; indication of PAPL listing status;

indication of radiation hardness status. Any format which includes the required information may be used. The initial PIL and subsequent updates shall be submitted in accordance with the contract schedule, and will contain information available at the time of preparation. Updates shall identify the changes to the previous submissions.

5.3.1 AS-BUILT PARTS LIST

In addition to the PIL, the contractor shall prepare and submit an As-Built Parts List (ABPL) to GSFC. The ABPL shall include all of the information required for the PIL, and in addition shall also include: quantities; lot date codes; parts use location to the sub-assembly level. ABPL submission shall be part of the end-item data package in accordance with the contract schedule.

5.4 ALERTS

As a member of the Government Industry Data Exchange Program (GIDEP), the contractor shall be responsible for reviewing and dispositioning all Alerts for applicability to the parts proposed for use. In addition, any NASA Alerts and Advisories provided to the contractor by GSFC shall also be reviewed and dispositioned. The contractor shall submit responses to the Alerts on applicability of the problem to the project usage, what hardware/software is affected, part location, and actions to be taken.

SECTION 6

MATERIALS AND PROCESSES CONTROL REQUIREMENTS

6.1 GENERAL REQUIREMENTS

The contractor shall plan and implement a comprehensive Materials and Processes (M&P) Program in accordance with the requirements of this Section and Section 1.3. The activities of the M&P program shall begin with the design stage of the hardware and shall help ensure the safety and success of the mission by the proper selection and treatment of the materials of construction.

6.2 SELECTION REQUIREMENTS

6.2.1 CONVENTIONAL APPLICATIONS

Selection of materials and processes shall be based upon past performance, available data, or current tests. The contractor shall utilize the applicable documents listed in Appendix A.

6.2.2 NONCONVENTIONAL APPLICATIONS

Any use of a material for which there is a lack of aerospace experience, such as composites or brittle ceramic materials, shall be considered a nonconventional application. In that case, the material shall be verified for the desired application on the basis of similarity, analysis, test, inspection, existing data, or a combination of these methods.

6.2.3 SPECIAL PROBLEM AREAS

The contractor shall give special attention to problem areas such as radiation effects, stress-corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled detectors, weld heat-affected zones and composite materials. Critical high-strength fasteners and pressurized systems shall be reviewed from a structural integrity viewpoint (see par. 4.3) before they are accepted for use.

6.2.4 ORGANIC MATERIALS

Materials shall be noncombustible or self-extinguishing to the greatest extent possible and conform with the flammability requirements of section 4.11 above. The outgassing characteristics of
organic materials in vacuum shall be a prime consideration in their selection. Only those organic materials with a total mass loss (TML) of less than 1.00 percent and a collected volatile condensable mass (CVCM) of less than 0.10 percent when tested in accordance with ASTM Method E595-77 (Appendix A), are acceptable for general spaceflight use. Specific mission contamination

control requirements may dictate more stringent outgassing criteria.

6.2.5 INORGANIC MATERIALS

The criteria specified in MSFC-SPEC-522 (see Appendix A) shall be used to select metallic materials to control stress corrosion cracking. Those materials that do not meet the criteria for acceptability shall be defined as noncompliant materials. If any use of such materials is planned, a request to use them including the rationale for such use shall be documented in accordance with MSFC-SPEC-522 in a Material Usage Agreement (MUA) (Figure 6-1a) along with a Stress Corrosion Evaluation Form (Figure 6-1b), and be submitted in accordance with par. 6.4c.

6.2.6 CONSIDERATIONS IN PROCESS SELECTION

Manufacturing processes shall be carefully selected if they are the type that may substantially change a material's properties (e.g., heat treatment, welding, chemical or metallic coatings). The objectives are to maintain the integrity of the materials and to avoid introducing property changes which could cause adverse effects.

6.2.7 SHELF LIFE CONTROLLED ITEMS

Polymeric materials that have a limited shelf life shall be controlled by a program that identifies the starting date (i.e., manufacturer's processing date, shipment date, or date of receipt, etc), the storage conditions associated with a specified shelf life, and the expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings, and paints shall be included. The use of materials whose date-code has expired requires Material Review Board (MRB) approval based on an adequate justification of need (such as schedule impact) and the contractor's demonstration by means of appropriate tests that the properties of the materials have not been compromised for their intended use. Fabricated items such as "O" rings that have out-of-date codes shall not be installed in flight hardware.

6.3 MATERIALS REVIEW

A contractor materials engineer shall review the applications of the proposed materials and processes on the basis of engineering drawings before approving their use. He shall also audit and consult with all subtier contractor's and vendors to assure that their materials and processes are acceptable for the applications.

6.4 DOCUMENTATION

The following shall be submitted to GSFC in accordance with GSFC-422-12-12-04 (CDRL):

a. Data supporting nonconventional application of materials.

b. Engineering drawings for materials application.

c. Material Usage Agreement/Stress Corrosion Evaluation Form (per MSFC Spec 522) when use of a noncompliant material is requested (Figures 6-1a and 6-1b).

d. Polymeric Materials List. The list shall be prepared and documented on GSFC Form 18-59B (Figure 6-1c).

e. Inorganic Materials List. The list shall be prepared and documented on GSFC Form 18-59A (Figure 6-1d).

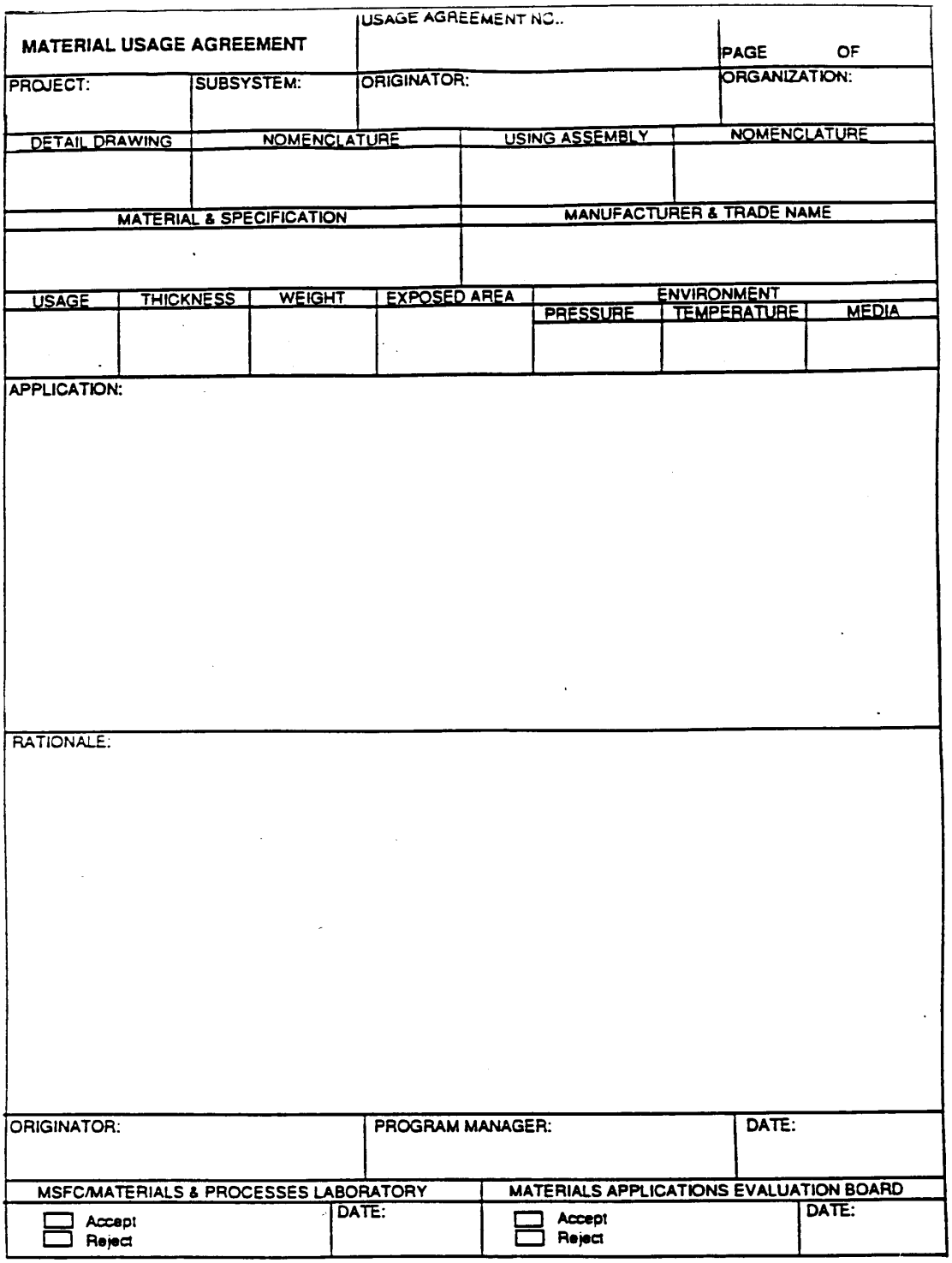
f. Lubrication List. The list shall be prepared and documented on GSFC Form 18-59C (Figure 6-1e).

g. Materials Processes List. The list shall be prepared and documented on GSFC Form 18-59D (Figure 6-1f).

h. As built materials list.

All the above listed items shall at least be submitted in hard-copy form. In addition, submissions of items d, e, f, g and h shall also include a copy of the data on a magnetic medium as a database file in DBF format (preferred) or as an ASCII file in SDF file format (with hard-copy documentation of file structures and file names). The required medium is flexible disk(s) compatible with IBM-PC DOS or MS DOS. The disks may be (1) 5.25 inch, double-sided, double-density (DS-DD), 360 kilobyte, (2) 5.25 inch high density (HD), 1.2 megabyte, (3) 3.5 inch, DS-DD, 720 kilobyte, or (4) 3.5 inch, HD, 1.4 megabyte.

The contractor may use his own system of reporting on both of the required media if it provides all the information requested by the GSFC forms and is approved by the Contracting Officer.



MATERIAL USAGE AGREEMENT	USAGE AGREEMENT NO..	PAGE OF

PROJECT:	SUBSYSTEM:	ORIGINATOR:	ORGANIZATION:

DETAIL DRAWING	NOMENCLATURE	USING ASSEMBLY	NOMENCLATURE

MATERIAL & SPECIFICATION	MANUFACTURER & TRADE NAME

USAGE	THICKNESS	WEIGHT	EXPOSED AREA	ENVIRONMENT		
				PRESSURE	TEMPERATURE	MEDIA

APPLICATION:

RATIONALE:

ORIGINATOR:	PROGRAM MANAGER:	DATE:

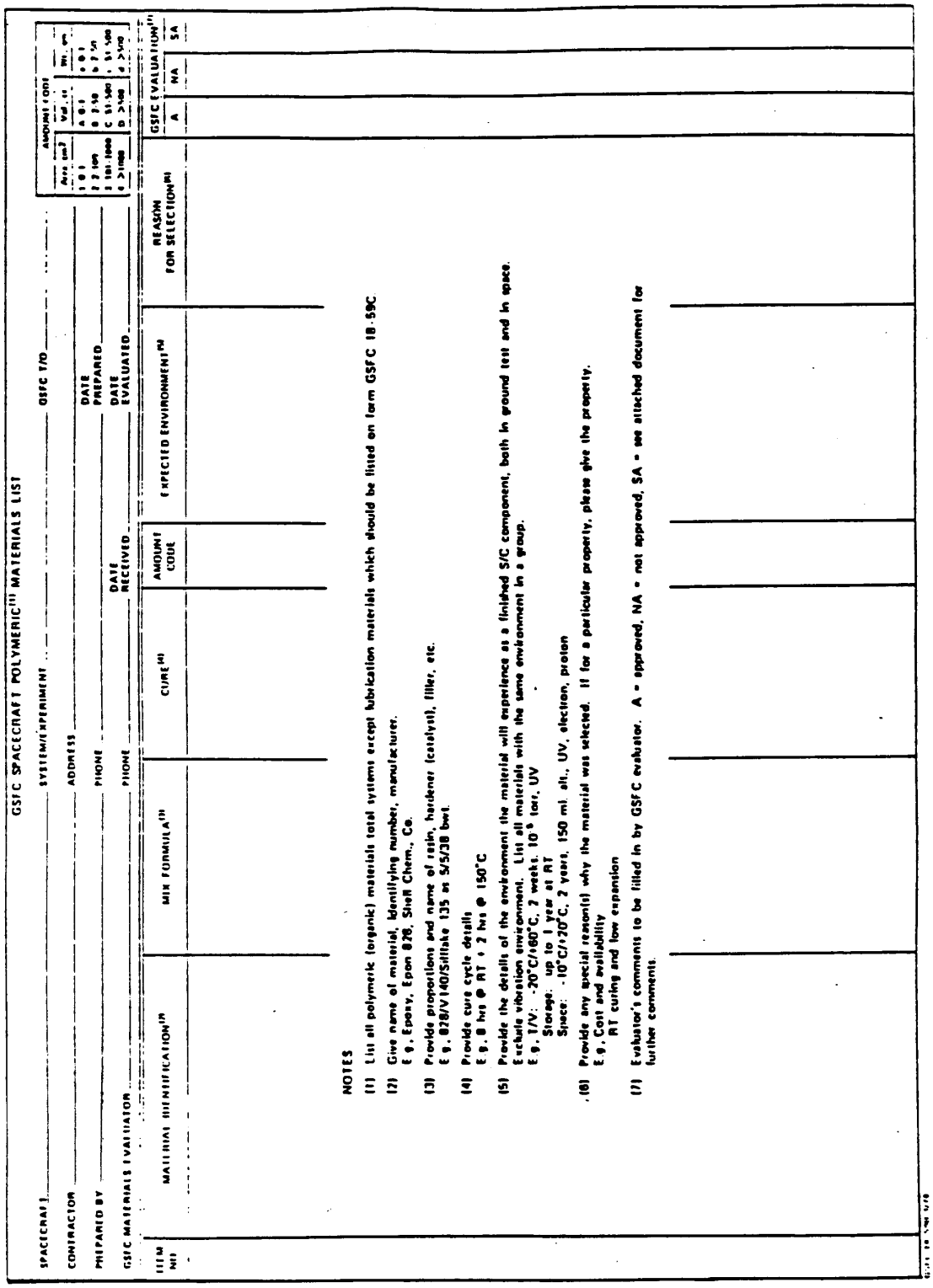
MSFC/MATERIALS & PROCESSES LABORATORY		MATERIALS APPLICATIONS EVALUATION BOARD	
☐ Accept ☐ Reject	DATE:	☐ Accept ☐ Reject	DATE:

Figure 6-1a Materials Usage Agreement Form (MSFC-SPEC-522)

STRESS CORROSION EVALUATION FORM

1. Part Number _____
2. Part Name _____
3. Next Assembly Number _____
4. Manufacturer _____
5. Material _____
6. Heat Treatment _____
7. Size and Form _____
8. Sustained Tensile Stresses-magnitude and Direction
   a. Process Residual _____
   b. Assembly _____
   c. Design, Static _____
9. Special Processing _____
10. Weldments
    a. Alloy Form, Temper of Parent Metal _____
    b. Filler Alloy, if none, indicate _____
    c. Welding Processes _____
    d. Weld Bead Removed - Yes ( ), No. ( ) _____
    e. Post-Weld Thermal Treatment _____
    f. Post-Weld Stress Relief _____
11. Environment _____
12. Protective Finish _____
13. Function of Part _____
14. Effect of Failure _____
    _____
15. Evaluation of Stress Corrosion
    Susceptibility _____
16. Remarks: _____
    _____

Figure 6-1b Stress Corrosion Evaluation Form



GSFC SPACECRAFT POLYMERIC[1] MATERIALS LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/D _____

CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

AMOUNT CODE

	Area, cm²	Vol., cc	Wt., gm
1	0-1	A 0-1	0-1
2	2-10	B 2-10	2-50
3	101-1000	C 51-500	51-500
4	>1000	D >500	>500

ITEM NO.	MATERIAL IDENTIFICATION[2]	MIX FORMULA[3]	CURE[4]	AMOUNT CODE	EXPECTED ENVIRONMENT[5]	REASON FOR SELECTION[6]	GSFC EVALUATION[7] A	NA	SA

NOTES

(1) List all polymeric (organic) materials total systems except lubrication materials which should be listed on form GSFC 18-59C

(2) Give name of material, identifying number, manufacturer.
E.g., Epoxy, Epon 828, Shell Chem., Co.

(3) Provide proportions and name of resin, hardener (catalyst), filler, etc.
E.g., 828/V140/Silitake 135 as 5/5/38 bwt.

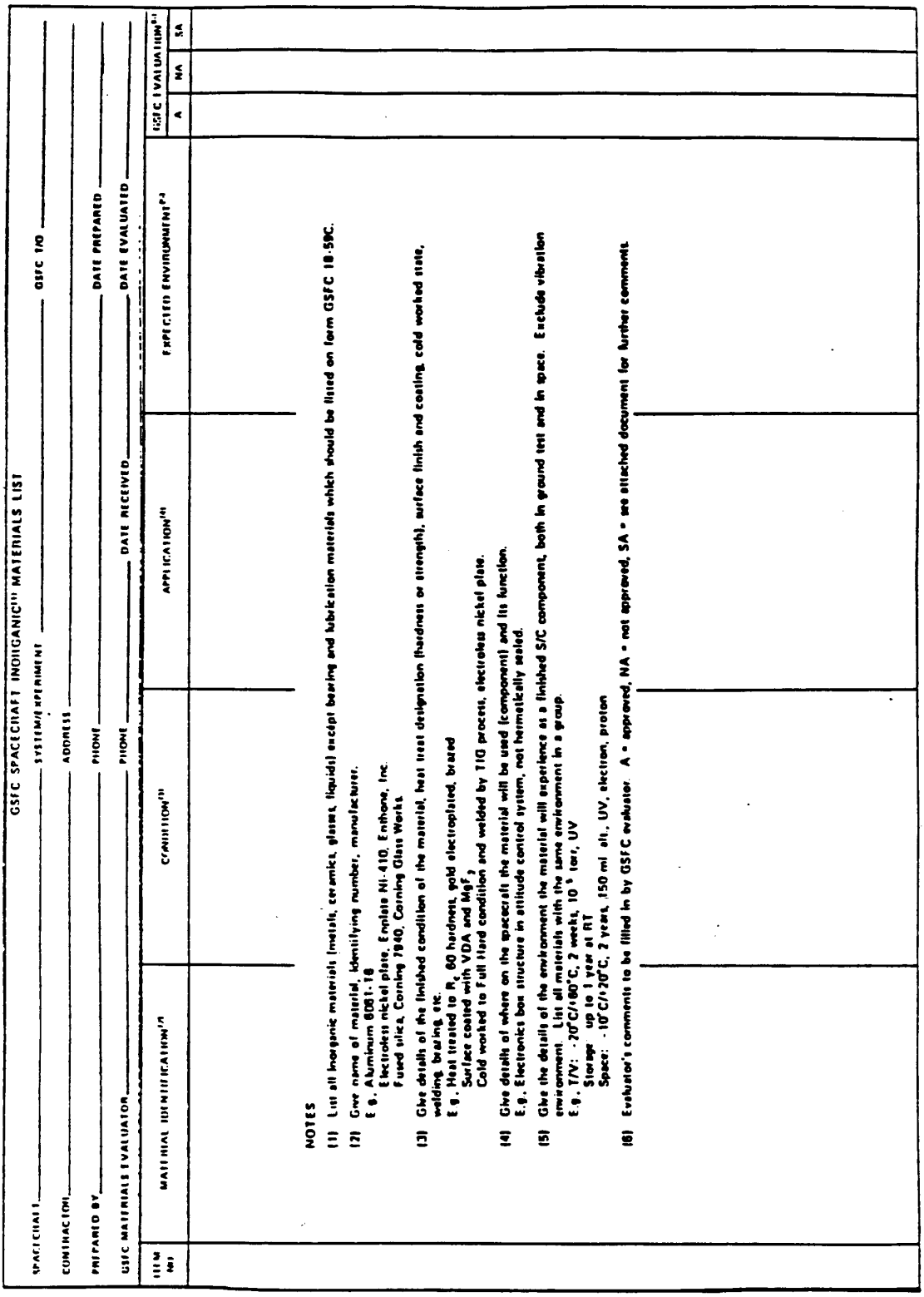
(4) Provide cure cycle details
E.g., 8 hrs @ RT + 2 hrs @ 150°C

(5) Provide the details of the environment the material will experience as a finished S/C component, both in ground test and in space.
Exclude vibration environment. List all materials with the same environment in a group.
E.g., T/V: -20°C/+60°C, 7 weeks, 10^{-5} torr, UV
Storage: up to 1 year at RT
Space: -10°C/+20°C, 2 years, 150 mi. alt., UV, electron, proton

(6) Provide any special reason(s) why the material was selected. If for a particular property, please give the property.
E.g., Cost and availability
RT curing and low expansion

(7) Evaluator's comments to be filled in by GSFC evaluator. A = approved, NA = not approved, SA = see attached document for further comments.

Figure 6-1c GSFC Spacecraft Polymeric Materials List



GSFC SPACECRAFT INORGANIC[1] MATERIALS LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC I/O _____

CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

ITEM NO.	MATERIAL IDENTIFICATION[2]	CONDITION[3]	APPLICATION[4]	EXPECTED ENVIRONMENT[5,6]	GSFC EVALUATION[6,7] A	NA	SA

NOTES

(1) List all inorganic materials (metals, ceramics, glasses, liquids) except bearing and lubrication materials which should be listed on form GSFC 18-59C.

(2) Give name of material, identifying number, manufacturer.
E.g. Aluminum 6061-T6
Electroless nickel plate, Enplate NI-410, Enthone, Inc.
Fused silica, Corning 7940, Corning Glass Works

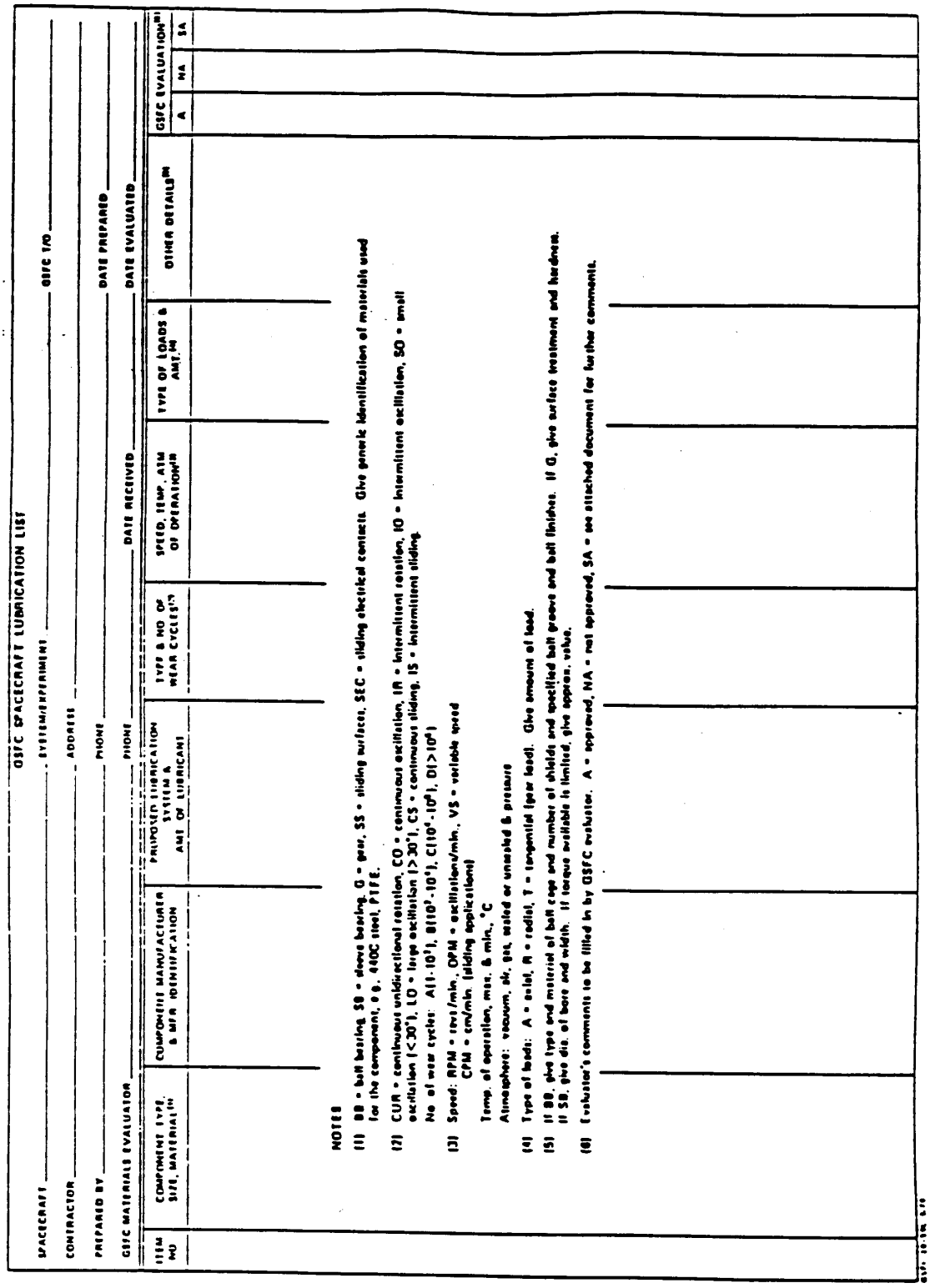
(3) Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
E.g. Heat treated to R_c 60 hardness, gold electroplated, brazed
Surface coated with VDA and MgF_2
Cold worked to full hard condition and welded by TIG process, electroless nickel plate.

(4) Give details of where on the spacecraft the material will be used (component) and its function.
E.g. Electronics box structure in attitude control system, not hermetically sealed.

(5) Give the details of the environment the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
E.g. T/V: $-20^{\circ}C/+60^{\circ}C$, 2 weeks, 10^{-5} torr, UV
Storage: up to 1 year at RT
Space: $-10^{\circ}C/+20^{\circ}C$, 2 years, 150 mil all, UV, electron, proton

(6) Evaluator's comments to be filled in by GSFC evaluator. A = approved, NA = not approved, SA = see attached document for further comment.

Figure 6-1d GSFC Spacecraft Inorganic Materials List



GSFC SPACECRAFT LUBRICATION LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC I/O _____

CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

ITEM NO	COMPONENT TYPE, SIZE, MATERIAL[1]	COMPONENT MANUFACTURER & MFR IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT OF LUBRICANT	TYPE & NO OF WEAR CYCLES[2]	SPEED, TEMP., AIM OF OPERATION[3]	TYPE OF LOADS & AMT.[4]	OTHER DETAILS[5]	GSFC EVALUATION[6] A	NA	SA

NOTES

(1) BB - ball bearing, SB - sleeve bearing, G - gear, SS - sliding surfaces, SEC - sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.

(2) CUR - continuous unidirectional rotation, CO - continuous oscillation, IR - intermittent rotation, IO - intermittent oscillation, SO - small oscillation (<30°), LO - large oscillation (>30°), CS - continuous sliding, IS - intermittent sliding.
No of wear cycles: A(1-10^3), B(10^3-10^4), C(10^4-10^5), D(>10^5)

(3) Speed: RPM - revl/min, OPM - oscillations/min, VS - variable speed
CPM - cm/min (sliding applications)
Temp. of operation, max. & min., °C
Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A - axial, R - radial, T - tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

(6) Evaluator's comments to be filled in by GSFC evaluator. A - approved, NA - not approved, SA - see attached document for further comments.

GSFC 561.4 6/70

Figure 6-1e GSFC Spacecraft Lubrication List

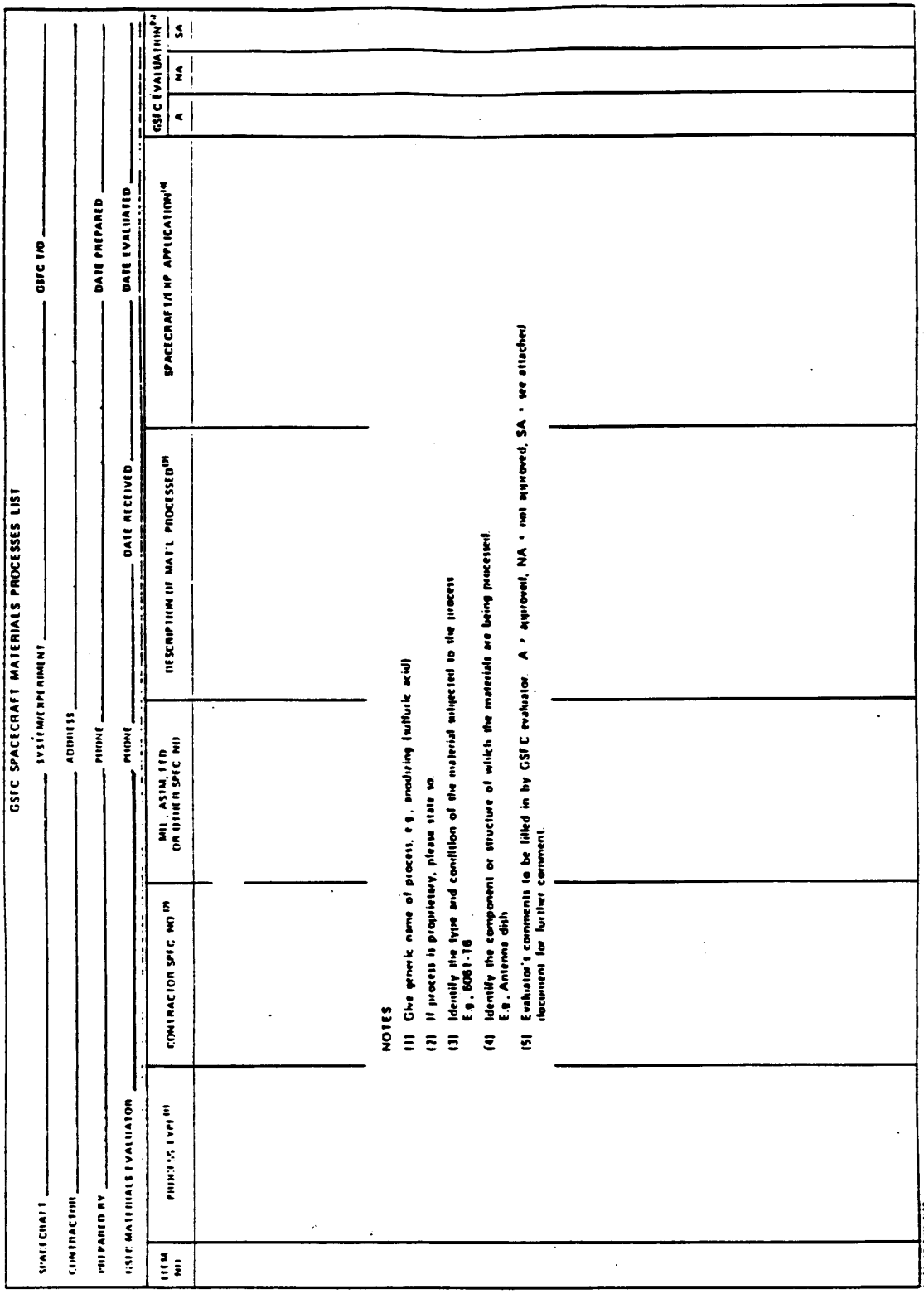


Figure 6-1f GSFC Spacecraft Materials Processes List

SECTION 7

DESIGN ASSURANCE AND RELIABILITY REQUIREMENTS

7.1 GENERAL REQUIREMENTS

The contractor shall plan and implement a design assurance program which addresses design changes to previous flight hardware and which interacts with other assurance program elements. The required elements of the design assurance and reliability program are outlined in this section.

7.2 DESIGN ASSURANCE

7.2.1 REQUIREMENTS

The contractor shall establish design criteria and standardize and control design practices. The designs shall be reviewed in accordance with paragraph 2.5 and be capable of:

a. Functioning properly during the required mission lifetime,

b. Minimizing or eliminating potential sources of human-induced failures,

c. Permitting ease of assembly, test, fault isolation, repair, servicing, and maintenance without compromising safety, reliability, quality, and performance.

7.2.2 SUPPORT FOR DESIGN ASSURANCE

Contractor assurance personnel shall specifically ensure that:

a. The quality, reliability, safety, and maintainability considerations are factored into new designs,

b. The design is capable of being inspected and tested and will facilitate repair,

c. The design is producible and repeatable,

d. The detailed design is in accordance with the controlling design criteria,

e. The performance, safety, and interface characteristics that require verification by analysis, inspection, and test are identified and reflected in appropriate lower-tier documentation.

f. All processes and operations in which uniform high quality cannot be assured by inspection alone are identified and controls are established to ensure hardware integrity.

g. Applications of fasteners are in conformance with GSFC specification S-313-100.

7.2.3 SPECIFICATIONS, DRAWINGS, AND TEST PROCEDURES

7.2.3.1 Design Specifications. The contractor shall prepare a design specification for each item of hardware at the instrument and component level. Each design specification shall identify the physical and functional requirements and interfaces of the specified item.

7.2.3.2 Specification, Drawing, and Test Procedures Reviews. The contractor's reliability organization shall review for concurrence all new design specifications, drawings and test procedures or shall ensure that they are independently reviewed before release.
The review shall ensure that the documents cover all items of hardware at the appropriate levels, that each is complete in its contents, and that each is functionally and physically consistent with interfacing design specifications, drawings, and procedures. Reviews shall also be conducted for changes to the documents.

7.3 RELIABILITY ANALYSES

Reliability analyses of new designs shall be conducted in accordance with the following paragraphs.

7.3.1 FAILURE MODES AND EFFECTS ANALYSIS (Mod 25)

A Failure Modes and Effects Analysis (FMEA) shall be performed to identify potential catastrophic and critical failures so that susceptibility to the failures and their effects can be eliminated from the system. A listing of all failure modes and severity level of the failure effects shall be provided. Catastrophic failures and critical failures are defined in Appendix B.

The analysis shall be performed for all electrical, electronic and electromechanical flight hardware. Critical mechanical and fluid systems shall also be included. The FMEA process shall be performed iteratively, as required, starting early in the design phase to ensure that the design and changes resulting from design reviews, analyses, waivers/deviations or other reasons do not introduce new failure modes or criticalities into the system.

The FMEA shall be conducted at the spacecraft-instrument and instrument-component interfaces. Potential component interface and/or observatory-instrument level catastrophic and critical failures shall be analyzed to the extent necessary to identify single parts that could cause the failures. Each FMEA shall be performed in accordance with GSFC P-302-720 "Performing a Failure Mode and Effects Analysis" or a contractor procedure that has been approved by the Contracting Officer. Because neither Metsat nor EOS have a 2-fault tolerance requirement (except for ignition sources [see par.6.2.4] and failures involving potential loss of

life or serious injury to personnel), for

purposes of the FMEA, the failure mode criticality classifications in GSFC P-302-720 shall be modified to read as follows:

> Criticality 1. A single failure that could result in loss of human life or serious injury to personnel, or loss of a launch facility, the launch vehicle, or a primary mission objective. (For failures involving potential loss of life or serious injury to personnel, redundant designs, both of which if failed would result in a Criticality 1 failure, shall be considered Criticality 1.)
>
> Criticality 2. A single failure that could result in damage to a launch facility or launch vehicle, significant degradation of science products (as defined by the Project), or loss of a secondary mission objective.
>
> Criticality 3. Loss of redundancy or an effect less severe than that of a Criticality 2 failure mode.

Analysis of redundant equipment shall address cross-strapping to ensure that no single failure will adversely affect the performance of the redundant capability. Spacecraft-instrument interface analyses shall identify any single failure that would affect spacecraft, instrument or other instrument performance. No single failure shall prevent the successful removal of power from a failed instrument. Potential catastrophic (Criticality 1) failures that cannot be eliminated from the system, and all potential critical (Criticality 2) failures, shall be itemized on a Critical Items List (CIL) that shall be attached to the FMEA. All part applications that do not conform with derating criteria (see par. 7.3.3) shall also be listed on the CIL. Justification for retention of each item listed shall be included. Although failure modes in redundant designs are assumed to be compensated by the redundancy (and therefore not be "single failure points") for purposes of the FMEA, that assumption cannot be relied upon in dealing with design errors or test failures in redundant systems, since generic design or workmanship deficiencies in a redundant item have the potential of affecting all the redundant items of that design.

The FMEA with the attached Critical Items List and updates shall be submitted to NASA in accordance with GSFC-422-12-12-04 (CDRL).

7.3.2 RELIABILITY ASSESSMENT

The contractor shall use numerical reliability assessment techniques for: (a) sensitivity analyses; (b) evaluation of the effects of design trade-offs or configuration changes; and (c) evaluating the ability of the design to achieve mission life requirement. Results of these analyses shall be reported to cognizant design personnel for consideration in selection or updating of hardware designs and to assurance management for inclusion in the performance assurance status reports (par. 1.6).

The assessments shall be provided in accordance with GSFC-422-12-12-04 (CDRL).

7.3.3 PARTS AND DEVICES STRESS ANALYSES

Electrical, Electronic, and Electromechanical (EEE) parts and devices, as applied in circuits within each component, shall be subjected to stress analyses for conformance with the derating policy of MIL-STD-975 and the GSFC PPL (paragraph 5.3.3). The analyses shall be performed at the most stressful part-level parameter values that can result from the specified performance and environmental requirements on the assembly or component. The analyses shall be performed in close coordination with the packaging reviews and shall be required input data for component-level design reviews (paragraph 2.5).
The analyses shall be documented, and justification shall be included for all applications which do not meet the derating criteria; these shall be submitted to the PCB (par. 5.3) for approval and shall be specifically reported in the contractor review summaries (see paragraphs 2.5 and 1.6). All part applications which do not meet the derating criteria shall also be listed on the CIL (see par. 7.3.1). The analyses and updates shall be made available to GSFC upon request.

7.3.4 WORST CASE ANALYSES

Worst Case Analyses shall be performed for critical parameters that are subject to variations that could degrade performance and for critical designs within the system hardware. Adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items shall be demonstrated by analyses or test or both. The form of the analysis shall be appropriate to the type of hardware being analyzed; e.g. ray trace analysis for optics, tolerance build-up for mechanical fit, or computerized analyses for more complex electronics. The analyses shall consider all parameters set at worst-case limits and worst-case environmental stresses for the parameter or
operation being evaluated. The analyses shall be updated as part of design changes. The analyses and updates shall be made available to GSFC upon request.

7.3.5 PERFORMANCE TREND ANALYSES

The contractor shall assess the instrument and it's components to determine measurable parameters that relate to performance stability. The parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases of the instrument and spacecraft. The monitoring shall be accomplished within the normal test framework; i.e., during functional tests, environmental tests, etc. The contractor shall establish a system for recording and analyzing the parameters as well as any changes from the first observed value even if the levels are within specified limits. A list of parameters to be monitored and the trend analysis reports shall be submitted in accordance with GSFC-422-12-12-04 (CDRL). Trend analysis data shall be reviewed with the operational personnel prior to launch, and the operational personnel shall continue

recording trends throughout mission life for early detection of possible mission failure tendencies.

7.4 LIMITED-LIFE ITEMS

Limited-life items shall be identified on a Limited-Life List and submitted in accordance with GSFC-422-12-12-04 (CDRL). The list shall include the expected life and the rationale for the selection of each item. Limited-Life items include all hardware that is subject to degradation because of age, operating time, or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined.

7.5 RELIABILITY OF GOVERNMENT-FURNISHED PROPERTY (GFP)

When the overall instrument includes components or other elements furnished by GSFC, the contractor shall be responsible for identifying and requesting from the NASA project office adequate reliability data on the items. The data will be used for performing the reliability analyses (par. 7.3).

SECTION 8

QUALITY ASSURANCE REQUIREMENTS

8.1 GENERAL REQUIREMENTS

The contractor shall establish, document, and ensure compliance with design control requirements and quality criteria during all phases of contract work. The contractor shall set forth his methods for meeting the quality assurance (QA) requirements of the project in all its phases. The plan shall ensure that controls are carried out according to schedule. GSFC shall be kept informed of the status of the QA program by the submittal of reports in accordance with paragraph 1.6.

8.2 SUPPORT OF DESIGN REVIEWS

QA personnel shall participate in the design reviews described in Section 2.

8.3 DOCUMENT CHANGE CONTROL

The contractor shall ensure control of all documents and changes thereto that affect the hardware and software. Quality assurance personnel shall ensure that documents and changes are controlled in accordance with the Project Configuration Management Plan. The contractor shall ensure that the effectivity of documents and changes is clearly specified, changes are accomplished on affected articles, and changed articles are appropriately identified. Documents shall be kept current and all fabrication, inspections, and tests shall be performed according to the most recent drawings and changes. The inspection record of the product shall indicate the change level with which it is in compliance.

The issue numbers of the drawings and specifications to which the particular hardware has been fabricated, inspected, and tested shall be documented (including photographs) as the as-built configuration. Evidence shall be provided of compliance with the as-built documentation as a basis for acceptance of the hardware. This information shall be submitted as part of the Acceptance Data Package (8.23). A contractor QA representative shall be a member of the Configuration Control Board. The QA activities shall be defined in the Configuration Management Plan and described in detail in the QA Plan; related portions of the plans shall be cross-referenced.

8.4 IDENTIFICATION AND TRACEABILITY

8.4.1 REQUIREMENTS

The contractor shall maintain a product identification and tracking system. Each product shall be identified by a unique part or type number, consistent with the configuration management system for the

contract. Where control of individual products or lots of products is

required, date codes, lot numbers, serial numbers, or other identification shall be used as appropriate. Serial numbers and lot numbers shall be assigned in consecutive order.

The system shall be capable of retrieving the identification and serialization record at the subassembly level. It shall also be capable of retrieving fabrication, processing and test records and photographs of identifiable articles, materials and parts (by part lot date code) in the event verification of the articles, materials or parts becomes necessary. Beginning at the subassembly level and continuing through the end product, the system shall be capable of tracing the location of any individual subassembly in the mission hardware at any given level of process, assembly, or test. Identification and serialization data lower than that for subassemblies shall be maintained in the manufacturing and processing records and shall contain date code, lot numbers, and manufacturer of the item; this includes mechanical parts and fasteners.
The contractor is encouraged to make use of his existing identification and traceability system. Serial numbers of scrapped products shall not be reused.

8.4.2 IDENTIFICATION LISTS

The contractor shall maintain an Identification List which distinguishes between prime contractor-designed ("make") and supplier-designed ("buy") products. The list shall indicate the part or type number and the group and individual identification. The list shall be a part of the configuration management system and changes shall be in accordance with paragraph 8.3 and shall be available to GSFC on request.

8.5 PROCUREMENT REQUIREMENTS

The following detailed quality assurance requirements, as applicable, shall be included or referenced in the procurement documents, in addition to those requirements selected in conformance with paragraph 1.8.2.

8.5.1 PRODUCT CHANGES

The supplier shall notify the contractor of proposed changes to products (including changes in design, fabrication methods, processes or location, and changes which may affect the quality or intended end use of the item). The supplier shall submit these changes to the contractor for processing in accordance with the contractor's Configuration Management Plan.
When a proprietary item is procured by the prime contractor, the supplier shall also notify the contractor of those changes.

8.5.2 PURCHASED RAW MATERIALS

Raw materials purchased by the contractor shall be accompanied by the results of chemical, and physical tests performed on the lots

of

material delivered. When material is purchased, the suppliers of raw materials shall be required to furnish specimens for chemical and physical tests in the event that the materials are later used for critical design applications.

8.5.3 RAW MATERIALS USED IN PURCHASED PRODUCTS

The supplier shall document and make available to the contractor on request the results of acceptance tests and analyses performed on raw materials.

8.5.4 AGE CONTROL AND LIMITED-LIFE PRODUCTS

Records shall be kept on products that have definite characteristics of quality degradation or drift with use, age or storage conditions. These shall include any materials to be used in fabrication, the shelf-life controlled items defined in paragraph 6.2.7, and the Limited Life items cited in paragraph 7.4. The records shall note the date, test time, or cycle when useful life was initiated, the life or cycles used, and the date, test time, or cycle when useful life will be expended.

8.5.5 INSPECTION AND TEST RECORDS

The contractor shall specify that the supplier maintain inspection and test records as evidence of inspection and test results. The contractor shall also specify records that are to be provided with
the deliverable item.

8.5.6 GOVERNMENT SOURCE INSPECTION (GSI)

When the Government elects to perform inspection at a supplier's plant in accordance with paragraph 8.7, the following statement shall be included in the procurement document:

"All work on this order is subject to inspection and test by the Government at any time and place. The Government quality representative who has been delegated NASA quality assurance functions on this procurement shall be notified immediately upon receipt of this order. The Government representative shall also be notified 48 hours in advance of the time that articles or materials are ready for inspection or test."

8.5.7 PROCUREMENTS THAT DO NOT REQUIRE GOVERNMENT SOURCE INSPECTION (GSI)

Procurements that do not require GSI shall include the following statement:

"The Government has the right to inspect any or all of the work included in this order at the supplier's plant."

8.5.8 WELD FILLER METAL AND FASTENER INTEGRITY

Weld rods, weld wire, and such procurements shall meet the requirements of MSFC-STD-655 (Appendix A).

Procurement, application, screening, inspection and test of fasteners shall conform with the requirements of GSFC specification S-313-100.

8.5.9 CONTRACTOR QA ACTIVITY AT SOURCE

When contractor QA activity is required at a supplier's plant as determined by paragraph 8.8, the procurement document shall so indicate.

8.5.10 RESUBMISSION OF NONCONFORMING ARTICLES OR MATERIALS

Nonconforming articles and materials returned to the supplier by the contractor and subsequently resubmitted by the supplier shall bear adequate identification of such resubmission. Reference shall be made to the contractor's nonconformance document, and evidence provided that the causes for the nonconformance have been corrected and actions have been taken to preclude recurrence.

8.6 REVIEW AND APPROVAL OF PROCUREMENT DOCUMENTS

Quality assurance personnel shall review and approve procurement documents before their release to ensure that applicable requirements of this document are included. The reviews shall be documented.

8.7 PROCUREMENT REVIEW BY THE GOVERNMENT

The contractor shall forward procurement documents to the Government representative to review for compliance with contract requirements and to determine the need for Government source inspection.
Such Government inspection shall not replace contractor source inspection or relieve the contractor of his responsibilities for product reliability, quality, and safety.

8.8 CONTRACTOR SOURCE INSPECTION

The contractor shall perform source inspection at the subcontractor's or supplier's facilities when directed by the procurement documentation or when one or more of the following conditions exist:

a. In-process, end-item controls, or tests that are destructive in nature prevent the contractor from verifying quality in the contractor's facility.

b. It is not feasible or economical for the contractor to determine the quality of procured articles solely by inspections or tests performed at the contractor's facility.

c. Qualification tests are to be performed by the subcontractor or supplier.

d. Products are shipped directly from the source to NASA, by-passing the contractor's inspection facilities.

8.9 CONTRACTOR RECEIVING INSPECTION

A controlled, documented receiving inspection system that covers all purchased products is required to ensure compliance with procurement documents.

All procured products shall be processed through an incoming inspection and testing system prior to fabrication. Nondestructive evaluation (NDE) may be used provided controlled documentation and certified personnel are employed. The receiving-inspection system shall consist of the following:

a. Procured products shall be accompanied by inspection and test records as evidence that the supplier is in compliance with purchase requirements and shall be accompanied by the required data directly traceable to the products. The records shall give evidence of contractor and Government source inspection.

b. Inspections and tests shall be conducted in accordance with written procedures on selected characteristics of the products to verify their acceptability. Particular emphasis shall be placed on the selection of characteristics that have not been contractor-source inspected and those for which nonconformances are difficult to detect during subsequent inspection and test. Test results shall be compared on a sample basis with test results provided by the supplier. Disassembly shall be performed periodically for detailed verification when required by the procurement document or the procedures.

c. The supplier's age control and limited-life product records shall be updated to reflect the receiving inspection activity.

d. When, during the design phase, it is determined that a material has a critical application, specimens of the material shall be delivered with the purchased product and be subjected to chemical and physical tests. Chemical analyses and physical tests shall also be performed on samples randomly selected from each lot of materials in order to verify the product's conformance to specification requirements. It shall be verified that all weld filler metal is in compliance with MSFC-STD-655.

e. Products and their records shall show acceptance or nonconformance status when released from receiving-

inspection, and the products shall be protected for subsequent handling or storage. Nonconforming products shall be submitted for Material Review Board (MRB) action. Items awaiting inspection or test results or MRB action shall be segregated.

f. Sampling inspection shall be used where tests are destructive or for such items as nuts, bolts, and fasteners that are not used as critical attachments (8.19).

g. Receiving inspection and test records shall be maintained, including copies of documents submitted by the supplier.

h. Documentation shall be provided showing that the electrostatic discharge control plan (8.12) is being complied with during receiving inspection.

8.10 FABRICATION CONTROL

8.10.1 FABRICATION AND ASSEMBLY FLOW PLAN

In addition to the general performance assurance requirements set forth in Section 1 (1.3 through 1.9), the contractor shall develop a Fabrication and Assembly Flow Plan (which includes major sub-contracts of 100K or greater) that covers all operations (from start of fabrication to delivery), including the inspections and tests, GSI inspection points, and all special processes to be used. A preliminary flow plan and a final flow plan shall be submitted in accordance with GSFC-422-12-12-04 (CDRL).

8.10.2 DOCUMENTATION

The contractor shall use a documentation system (consisting of items such as fabrication orders, assembly orders, shop travelers, repair procedures, and photographs) to document and control the flow of hardware through the manufacturing phase. Controls shall ensure that only conforming product is released and used during fabrication and that those not required for the operation involved are removed
from the work area and properly stored. Traceability shall be maintained in accordance with par. 8.4. Fabrication documents shall include or reference:

a. Nomenclature and identification of the article.

b. Tooling, jigs, fixtures, and other equipment to be used.

c. Characteristics and tolerances to be obtained.

d. Detailed procedures for controlling processes.

e. Special conditions to be maintained such as environmental conditions or precautions to be observed.

f. Workmanship standards per paragraph 8.10.3.

g. Controls for parts, materials, and articles which have definite characteristics of quality degradation or drift with age, use, or storage. The controls shall include requirements for recording and maintaining dates, time, or cycles for determining end of life.

h. Traceability to the individual and equipment performing each fabrication and assembly operation.

Contractor assurance personnel shall ensure that manufacturing operations are in compliance with up-to-date controlling documents.

8.10.3 FABRICATION REQUIREMENTS

The requirements of NHB 5300.4(3A-2), NHB 5300.4(3G), NHB 5300.4(3H), and NHB 5300.4(3J), (Appendix A), shall be implemented. Printed wiring boards shall be in accordance with requirements of MIL-STD-275 and MIL-P-55110 (see section 8.15.3.5). Workmanship standards may be used to show acceptance criteria. When samples showing acceptance criteria are necessary, they will be jointly selected by the contractor and NASA or its quality representative. Standards shall be kept current and shall be used to train, certify, and recertify personnel when appropriate. Any material used for torque striping must meet the requirements of materials selection and performance as specified in Section 6.0, Materials and Processes Control Requirements. In particular, as the material is typically a pigmented epoxy, it must meet the outgassing requirements specified in paragraph 6.2.4.

8.10.4 PROCESS EVALUATION AND CONTROL

Controls shall be implemented for processes for which high uniform quality cannot be ensured by inspection of products alone. Nondestructive evaluation (NDE) methods may be used provided controlled documentation and certified personnel are employed. Process procedures shall be prepared and shall describe the following:

a. Preparation of the processing equipment, solutions and materials.
b. Preparation of the products to be processed.
c. Detailed processing operations.
d. Conditions to be maintained during each phase of the process including environmental controls.
e. Methods of verifying the adequacy of processing materials, solutions, equipment, environments, and their associated control parameters.
f. Inspection and test provisions.
g. Records (and photographs where applicable) for documenting the results of process inspection, test, and verification.

The contractor shall provide for the certification of equipment used in selected processes. Records of certification test results shall be maintained. Equipment shall be recertified as indicated by the results of quality surveys, inspections, tests or when changes are made that may affect process integrity.

8.11 CONTAMINATION CONTROL

The quality assurance personnel shall ensure that the requirements of the Contamination Control Plan (Section 9) are being complied with during all phases of the program.

8.12 ELECTROSTATIC DISCHARGE CONTROL (Mod 25)

The contractor shall describe a program to control Electrostatic Discharge (ESD) for electrical and electronic parts, assemblies, and equipment susceptible to damage caused by static electricity. The program shall address provisions for work area protection, handling procedures, training, hardware protective covering, packaging for delivery, and Quality Assurance verification of conformance. Procedures for in-house ESD control shall be developed in accordance with NHB 5300.4 (3L), DOD-HDBK-263 and DOD-STD-1686. The contractor shall also invoke applicable requirements for ESD control on subcontractor's and suppliers in accordance with DOD-HDBK-263 and DOD-STD-1686.

8.13 NONCONFORMANCE CONTROL

The contractor shall operate a closed-loop nonconformance control system for failures and discrepancies. The system shall include provisions for the following:

a. Documentation of each nonconformance traceable to the specific product on which it occurred.

b. Assignment of a unique and traceable document number for each failure and for those discrepancies designated for Material Review Board (MRB) action.

c. Description of the nonconformance and the required characteristic or design criteria.

d. Conducting and documenting analyses and examinations to determine the cause.

e. Implementing and documenting timely and effective remedial and preventive action on the products and applicable documents.

f. Disposition of the nonconforming product.

g. Signatures of authorized personnel on the appropriate nonconformance documents.

h. Accumulating data in summary reports.

i. Performing analyses from the part level of assembly and higher to identify adverse trends and to provide for their correction.

j. Closeout of nonconformance documentation after verifying that effective remedial and preventive actions have been taken on the nonconforming articles and any other articles affected.

On request, a report of the analyses required by items d. and i. shall be made available to GSFC. Products that depart from specified requirements shall be identified and, if practicable, shall be isolated for review action. The system shall include provisions for controlling nonconforming products that cannot be isolated from the normal channels of manufacture.

8.13.1 CONTROL, DISPOSITION, AND REPORTING OF DISCREPANCIES

8.13.1.1 Documentation - Documentation of discrepancies shall start with the receipt of procured parts, materials, or other products, or the initiation of in-house manufacturing, whichever occurs first. Each discrepancy shall be documented on the appropriate contractor form promptly after discovery.

8.13.1.2 Initial Review Dispositions - Discrepant products shall be reviewed by contractor QA and, as appropriate, engineering personnel and shall be subjected to one of the following dispositions:

a. Return for Rework or Completion of Operations - The product shall be returned using established and approved documents and operations. During rework, the product shall be resubmitted to normal inspection and tests.

b. Scrap in accordance with Government-approved contractor procedures for identifying, controlling and disposing of scrap.

c. Return to Supplier - The contractor shall provide the supplier with nonconformance information and assistance, as necessary, to permit remedial and preventive action.

d. Submit to Material Review Board - When the dispositions, as described above, are not appropriate, the discrepant products shall be submitted to the Material Review Board (MRB) for final disposition.

Products disposed of without referral to MRB shall be subject to review by the Government quality representative. Initial review dispositions shall be recorded on nonconformance documentation.

8.13.1.3 Material Review Board (MRB) - MRB decisions on nonconformance shall be submitted to NASA in accordance with GSFC-422-12-12-04 (CDRL). Other provisions of the MRB follow:

a. Membership. The MRB shall comprise, as a minimum, the following members:

1) Contractor quality representative, chairman.

2) Contractor engineering representative.

3) Government quality representative.

The contractor shall select members on the basis of technical competence. The Government representative on the board shall approve the membership.

b. Responsibilities - The MRB shall have the responsibility to:

1) Determine disposition of submitted products. NOTE: All MRB decisions that are not unanimous must be referred to higher authority (contractor and NASA) for resolution.

2) Ensure that remedial and preventive actions, including reinspection and retest requirements, are recorded on the nonconformance document prior to disposition.

3) Perform trend analysis of discrepancies.

4) Ensure that MRB records are maintained.

c. Dispositions - In addition to the dispositions listed in 8.13.1.2, the MRB shall have authority for the following:

1) Repair - The MRB shall approve repairs, except as noted below. Standard Repair Procedures shall be submitted to GSFC in accordance with GSFC-422-12-12-04 (CDRL). The MRB shall authorize the use of the procedures for each instance of repair. The MRB shall ensure that the hardware reliability and quality are not compromised by excessive repairs.

2) Scrap.

3) Use-as-is. (Except as stated below. Also, see NOTE).

MRB disposition shall not adversely affect the safety, reliability, durability, performance, interchangeability, weight, or other basic features of the hardware.

Dispositions that, in the opinion of the MRB, will adversely affect any of the foregoing or which are contrary to any of the requirements of the contract must be submitted as a waiver request (see Figure 4-3, herein) to the Contracting Officer for approval in accordance with the project Configuration Plan, (paragraph 8.3 and GSFC-422-12-12-04 (CDRL).

NOTE: The products shall be withheld from further processing in a controlled area until direction for disposition is given by the Contracting Officer.

8.13.1.4 Supplier Material Review Board - The contractor may, with approval of GSFC or its authorized quality representative, delegate MRB responsibility to suppliers.

8.13.2 CONTROL, REPORTING, AND DISPOSITION OF FAILURES

8.13.2.1 Failure Reporting. A Problem/failure Report (PFR) shall be written for each departure from design, performance, testing, or handling requirements that affects the function of the instrument or could possibly compromise mission objectives. This includes portions of the test equipment (GSE) that interfaces with and supply power to the flight equipment. These requirements shall be flowed-down by the contractor to major subcontractors (i.e, greater than 100K).

Other problems or anomalies that are unusual or that might affect other areas shall also be cited on a PFR.

Reporting of hardware failures shall begin with the first power application at the lowest level of assembly or the first operation of a mechanical item; it shall continue through formal acceptance by the NASA project office and the postlaunch operations, as required by the contract. For software problems, operation of this PFR system shall begin with the first test use of the software item with a hardware item of the mission system at the component level or higher.

a. Report Processing- A PFR shall be initiated immediately after the failure has occurred. (See Figure 8-1a for a sample report form). The contractor / subcontractor may use his existing form for reporting if it complies with the requirements of the GSFC PFR form and is approved by the Contracting Officer. The report shall be filled out in accordance with the instructions on Figure 8-1b. It shall be given an Failure Effect Rating as soon as practicable (see par. 8.13.2.3), to be labeled and noted in Block 32 of the form. It shall also be given a Failure Corrective Action Rating as soon as the failure

has been analyzed and the corrective action devised. This shall be

noted in Block 33 of the form in accordance with the Risk Rating criteria stated in paragraph 8.13.2.3, below. The Failure Corrective Action Rating shall be updated if appropriate, based on technical re-assessment prior to close-out and this final Failure Corrective Action Rating noted by updating Block 33 of the form.

The reports shall be submitted to NASA in accordance with GSFC-422-12-12-04 (CDRL) and the identical information shall be given to the in-plant Government quality representative. The PFR data shall be submitted in hard copy and in a computer readable form which shall be as a database file in DBF format (preferred) or as an ASCII file in SDF file format (with hard-copy documentation of file structures and file names). The required medium is flexible disk(s) compatible with IBM-PC DOS, MS DOS, or other compatible DOS.

The disks may be (1) 5.25 inch, double-sided, double-density (DS-DD), 360 kilobyte, (2) 5.25 inch high density (HD), 1.2 megabyte, (3) 3.5 inch, DS-DD, 720 kilobyte, or (4) 3.5 inch, HD, 1.4 megabyte. The hard copy submittals shall be made as the updating actions occur on each PFR, and the iteration submitted to NASA for closure shall include a copy of all referenced data and shall have had all corrective actions accomplished and verified.

PROBLEM / FAILURE REPORT

(1) TEST ELEMENT: FLT. ☐ HDW. ☐ SW GRD. ☐ HDW. ☐ SW TEST ☐ HDW. ☐ SW							PFR No.				Contractor Report No.	
(2) Project			(3) Spacecraft/Observatory					(4) Operation Time			(5) No. of Cycles	
(6) Sub-System/Instrument		(7) S/W Version		(8) Date & Time of Problem/Failure	Yr.	Mo.	Day	Time	(9) Date of Report	Yr.	Mo.	Day
(10) Originator (Last Name, First Name)			Phone						Organization (GSFC Code or Company)			
(11) Run Test ID												
(12) Supporting Information · ☐ Console Printout ☐ Dump Printout ☐ Error Codes [ ] Dump Tape No. ☐ Criticality ☐ Other												
(13) Problem / Failure Occurred During	☐ Bench / Unit Test ☐ Qualification Test		☐ Integration Test ☐ Acceptance		☐ Prelaunch Operations ☐ Launch Operations			☐ Other				
(14) Environment When Failed	☐ Acceleration ☐ Shock		☐ Thermal-Vacuum ☐ Temperature		☐ Humidity ☐ Vibration			☐ Ambient ☐ Vibration		☐ EMI / EMC ☐ Magnetics		
(15) Hardware/Integration Level When Failed	☐ Part ☐ Sub-Assembly		☐ Assembly ☐ Component		☐ Spacecraft Sub-System ☐ Instrument/Experiment			☐ Spacecraft/Observatory				
(16) Software/Integration Level When Failed	☐ OS ☐ User Interface		☐ Database ☐ Driver		☐ Communications ☐ Firmware			☐ Text ☐ Other				

NAME	IDENTIFICATION/REVISION NO.	SERIAL NO.	MANUFACTURER	CAGE CODE
(17) Component				
(18) Assembly				
(19) Sub-Assembly				
(20) Part	Manufacturer's Part Number	Date Code		

(21) Description of the Problem/Failure (attach additional sheets if necessary):

(22) Reference Certification Log Book #	Page	Test Procedure	Paragraph

(23) Cause of the Problem/Failure (attach additional sheets if necessary):

(24) Corrective Action Taken (attach additional sheets if necessary):

(25) If Corrective Action is Required on Other Units, List Units by Serial No.

(26) Failure Analysis Performed ☐ Yes ☐ No ☐ N/A — Failure Analysis Performed by GSFC Code / Contractor — Failure Analysis Report No.

(27) Action Taken on Failed Unit ☐ Rework ☐ Modified ☐ Discard ☐ Replace ☐ None ☐ PSMB/CCB ☐ Submit to MRB
Organization That Performed Rework/Repair: MRB No. Date:

(28) Is Retest Required After Corrective Action?
☐ Yes ☐ No If Yes, State Retest Requirements Date Completed

(29) Is Unit Suitable for Original Use?
☐ Yes ☐ No Remarks:

(30) Contractor Program Manager / FRB Approval
Signature: _____ Date: _____
Q A Signature: _____ Date: _____

(31) Safety ☐	(31) ·Failure Effect Rating ☐	(33) Failure Corrective Action Rating ☐	(34) Red Flag ☐ Yes, ☐ No

(35) GSFC Project Manger Approval:	Date::	(36) GSFC OFA Approval:	Date:

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Figure 8-1a GSFC Problem/Failure Report Form (Copy 1)

PROBLEM / FAILURE REPORT

Block (1) : Check appropriate block for element being tested.
P/FR #: Leave blank, # generated by computer when input into system. Contractor Report #: All off site contractor initiators fill in with the contractor unique tracking #.
Block (2) : All initiators, use project approved acronyms or project name.
Block (3) : All initiators, provide the project approved acronym or complete name of the spacecraft or observatory on which problem occurred.
Block (4) : Enter the elapsed time to the point where problem occurred to the tenth of hour.
Block (5) : If testing in cycles, enter the number of cycles elapsed in the pint where the problem/failure occurred.
Block (6) : All initiators, enter system of experiment name. Definitions: "System" - The next functional sub-division of a spacecraft generally composed of two or more components designed to perform an operation. Example: Electrical Communication System, Stabilization and Control System, etc. "Experiment" - The next functional sub-division of a spacecraft, generally a combination of two or more components, including both the sensor and associated electronics designed for acquisition of data for space research.
Block (7) : For software testing - enter the configuration nomenclature for the item being tested.
Block (8) : Enter date & time of problem/failure. Example - June 8, 1967 at E p.m. - Year 67 Day 08 Time 1500.
Block (9) : Enter Date the problem/failure report is originated. Example June 9, 1967 - Year 67 Month 06 Day 09.
Block (10) : Enter the complete/ last and first name, telephone number and organization (GSFC Code or Company) of the P/FR initiator.
Block (11) : For software enter the ID # of Run Test.
Block (12) : For software check the appropriate item, enter the appropriate dump tape number and enter the correct critically code CUR, Critical, Urgent, Routine.
Block (13) : Check the appropriate item indicating the type of test being conducted when the problem/failure occurred. If other is checked, describe in Block (21).
Block (14) : Check item that defines the actual environment the until was being subjected to when the problem/failure occurred. **Caution** for example, do not check vibration if unit failed during a function test prior to the actual application of the vibration environment, check ambient. If the environment in which the unit failed is not listed or the description listed does not give sufficient detail, give this information in Block (21).
Block (15) : Check item that defines the hardware level at the time of problem/failure. For example: If a power supply subassembly fails during communications systems test, check spacecraft sub-system.
Block (16) : Check item that defines the software level at time of problem/failure. If other is checked, describe in Block (21).
Block (17) : Enter component name. Definition: **"Component"** - The next functional sub-division of a system which is generally a self-contained combination of assemblies performing a function necessary to the systems operations. Example: Power, power supply, transmitter, gyro package, etc. Enter component identification number, serial number , the manufacturer's name, and the manufacturer's cage code.
Block (18) : Enter assembly name. Definition: **"Assembly"** - The next functional sub-division of a component which consists of parts or sub-assemblies which perform functions necessary to the operation of the component as a whole. Example: Regulator assembly, power amplifier assembly, etc. Enter the assembly identification number, serial number, manufacturer's name, and manufacturer's cage code.
Block (19) : Enter sub-assembly name. Definition: **"Sub-assembly"** - An assembly within a larger assembly. Example: Wired printed circuit board modules, etc. Enter sub-assembly identification number, serial number, manufacturer's name, and manufacturer's cage code.
Block (20) : Enter part name. Definition: **"Part"** - An element of a component, assembly or sub-assembly which is not normally subject to further sub-division or disassembly without destruction of designed use, Example: Resistors, transistors, diodes, etc. Enter manufacturer's part number, the manufacturer's name, date code, and manufacturer's cage code.
Block (21) : Enter all details of the problem/failure such, as inputs, outputs, tolerances, symptoms, abnormal conditions, testing phase, detail of environment and prior environment. Use additional sheets if necessary.
Block (22) : Enter reference information.
Block (23) : Enter detailed, concise narrative defining the actual direct cause of the problem/failure. Use additional sheets if necessary.
Block (24) : Enter detailed, but concise, narrative defining the corrective action taken. The corrective action shall be sufficient to preclude the problem/failure from occurring again. Use additional sheets if necessary.
Block (25) : List other units affected by the corrective action. Enter N/A if not applicable.
Block (26) : Check appropriate item and fill in requested information if appropriate.
Block (27) : Check appropriate item(s) and fill in requested information.
Block (28) : Check appropriate item and detail which tests if an need to be re-run. Enter date retest completed, if required.
Block (29) : Check appropriate item and provide supporting rationale, if any.
Block (30) : GSFC Hardware/software contractors (program manager/FRB chairman) fill out this block at completion of all actions.
Block (31-36) are for GSFC Project Failure Review Board use only. Refer to FAP P-303-849.
Block (31) : Check if failure involves a safety related item.
Block (32) : Choose appropriate: 1 - None or negligible; 2 - Moderate or significant; 3 - Major or catastrophic.
Block (33) : Choose appropriate: 1 - Known cause/certainty in corrective action, no possibility of recurrence; 2 - Unknown cause/certainty in corrective action, no possibility of recurrence; 3 - Known cause/uncertainty in corrective action, some possibility of recurrence; or 4 - Unknown cause/uncertainty in corrective action., some possibility of recurrence.
Block (34) : Check Yes of No, based on conditions of Blocks #32, #33. Refer to FAP P-303-849.
Block (35) : GSFC project manage approval.
Block (36) : GSFC project FAM approval to close.

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Figure 8-1b Instructions for entering data on the GSFC Problem/Failure Report Form

The submittal of the data in the above specified computer readable form shall be in monthly composited updates of all currently open PFR's (with each data item separately identified to its respective PFR). When each PFR is closed, the next monthly computer composite shall carry the closure update of all data on that PFR.

The contractor shall maintain a master report file which contains all supplementary data such as failure analysis and records of meetings.

b. Status Summaries - A summary of the open PFR's shall be submitted as part of the Performance Assurance Status Report (see section 1.6). The summaries shall list each problem or failure as a separate line item and provide complete identification of the affected hardware (part and serial numbers), the environment, date of occurrence, and a brief description of the failure, its cause, and the corrective action to be taken. Before removing any item from the "open" list, the last summary report shall show the corrective actions actually taken and the date closed.

8.13.2.2 Failure Review Board. A Failure Review Board (FRB) shall be established and, as a minimum, shall comprise the following:

a. Contractor quality or reliability representative (chairman).

b. Contractor project manager or his representative.

c. Contractor engineering representative who is responsible for the failed item.

d. Government quality representative.

The contractor shall select members on the basis of technical competence. The Government representative on the board shall approve the membership.

The FRB shall obtain the assistance of appropriate groups and personnel to ensure that all failures are investigated, analyzed, and their causes determined. Failures involving EEE parts shall be coordinated with the PCB (see section 5.4). Investigations and actions shall be coordinated with NASA and documented on a PFR. Trend analysis shall be performed and corrective action taken. Where it is determined that the affected item is discrepant, the FRB will refer it to the MRB for disposition in accordance with paragraph 8.13.1.3. Configuration changes, if required, shall be in accordance with paragraph 8.3 and the Metsat Configuration Management Plan. Closeout of each failure shall require verification that remedial and preventive actions have been accomplished in the item on which the failure occurred, that necessary preventive design changes in the item have been

accomplished and verified in test, and that effectivity of preventive actions has been established in other affected items.

The FRB chairman, denoting approval of the entire Board, shall sign the PFR closeout before submitting it to NASA in accordance with GSFC-422-12-12-04 (CDRL). In addition, "Red Flag" reports shall be signed off as prescribed in par. 8.13.2.3. PFR's shall not be considered closed until signed by the authorized Government representative.

8.13.2.3 DELETED (MOD 74)

8.14 ALERT INFORMATION

The contractor shall review Alerts and SAFE-Alerts that document problems with parts, materials, processes, and safety as reported through the Government-Industry Data Exchange Program (GIDEP). Also, GSFC may provide the contractor other special notices (e.g. NASA TWX alerts) of general problems. The contractor shall notify GSFC of any Alerts or problem notices which have or may have an effect on the contract hardware. In accordance with GSFC-422-12-12-04 (CDRL), the contractor shall submit responses to these Alerts and
problem notices, which inform GSFC of the applicability of the problem to project hardware and any follow-up action proposed. Status summaries covering each applicable Alert received in a 30-day period shall be submitted as part of the Performance Assurance Status Report (1.6). The contractor shall also respond to any specific GSFC inquiry on the applicability of any part or materials problem to the contract hardware. [If the contractor is not a member of GIDEP, GSFC may provide the contractor with selected Alerts and SAFE-Alerts, and the contractor shall review them and notify GSFC of problems potentially affecting the contract hardware.]

The contractor shall prepare Alerts on problems that are within the scope of the Alert system. If the contractor participates in GIDEP he shall submit a copy of the Alert to GSFC when submitting it to GIDEP. If he does not participate in GIDEP he shall prepare Alerts (DD Form 1938) and submit them and supporting data to GSFC for appropriate action in accordance with GSFC-422-12-12-04 (CDRL).

8.15 INSPECTIONS AND TESTS

The contractor shall plan and conduct an inspection and test program which demonstrates that contract, drawing, and specification requirements are met. Inspections and tests shall be performed on products before they are installed in the next level of assembly. Inspection shall include a review of product records. Each inspection and test shall be traceable to the individual responsible. Quality assurance personnel shall approve all manufacturing documentation prior to its use.

All inspections and tests shall be monitored/witnessed by QA personnel designated to perform quality program functions independent of operator/technician functions. QA personnel shall ensure adequacy of inspection, accept/reject criteria, equipment, compliance with program requirements, and other factors having an influence on product reliability and quality.

8.15.1 PLANNING

The contractor shall plan for inspections and tests and for a documentation system that substantiates their accomplishment. The planning function shall provide for:

a. Orderly and timely inspection and tests at the earliest opportunity and through all phases.

b. Coordination and sequencing of inspection and tests conducted at successive levels of assembly to ensure satisfactory articles and materials and to eliminate unnecessary testing.

c. Availability of handling equipment and calibrated inspection and test equipment.

d. Coordination of inspections and tests conducted by the designated Government Quality Representative.

e. A documented listing of those inspection procedures utilizing sampling plans (paragraph 8.19), including the sampling rationale. This shall be maintained as a part of the inspection planning documentation and shall be available to NASA for review upon request.

8.15.2 INSPECTION AND IN-PROCESS TEST PROCEDURES

Inspection and in-process test activities shall be conducted in accordance with documented procedures physically located at the applicable inspection or test station. The degree of detail in the procedures shall be commensurate with the complexity of inspection or in-process test operations. Inspection procedures may be a part of the manufacturing control documentation. All procedures shall include, as applicable, the nomenclature of the article, characteristics to be inspected or tested, accept/reject criteria, and special consideration regarding measuring or test equipment, standards, safety, and environment.

8.15.3 INSPECTION ACTIVITY

As a minimum the inspections in the following paragraphs are to be performed.

8.15.3.1 In-Process Inspection. This task shall be performed at all levels of assembly in keeping with the following requirements:

a. The configuration, drawing requirements, and workmanship shall be verified prior to the next step of fabrication or integration; characteristics shall be verified that cannot be verified later without destructive disassembly.

b. In-process inspection shall be done in a clean environment in accordance with the Contamination Control Plan (see par. 9.2).

c. In-process inspection personnel shall be certified for the selected processes and inspections.

d. In-process verification below the component level shall include electrical interface tests (paragraph 3.3.1) of assemblies prior to being integrated into the next higher level of hardware.

8.15.3.2 Final Inspection. This task shall be performed at all levels of assembly:

a. Configuration, workmanship, and test results shall be verified before installation or use with the next higher level of assembly.

b. Verify that all nonconformances have been processed and all open items have been transcribed into the next level of inspection or fabrication documents.

c. Final inspection shall be done in a clean environment in accordance with the Contamination Control Plan.

d. Final inspection personnel shall be certified for the selected processes and inspections.

8.15.3.3 End-Item Inspection. This task shall be performed to:

a. Verify that configuration, test results, workmanship, and the Acceptance Data Package (see par. 8.23) is in compliance with the contract.

b. Verify that NASA has authorized the delivery of the end-item with such open nonconformances and unresolved tasks that may exist.

8.15.3.4 Surveillance Inspection. Stored and stocked parts, materials, and flight or spare hardware shall be periodically inspected and tested for proper storage environment and packaging to prevent deterioration or damage. The contractor shall identify the hardware and the frequency of the inspection.

8.15.3.5 Printed Wiring Board Inspections and Tests. Printed wiring boards shall conform to the requirements of MIL-STD-275, MIL-P-55110, and shall be qualified by test and inspection results. Test coupons for all flight PWB's shall be submitted to NASA for evaluation in accordance with GSFC-422-12-12-04 (CDRL). Test coupons and printed wiring boards shall be traceable to the circuit board panels from which they have been cut.

8.15.4 QA ACTIVITIES DURING THE INTEGRATION AND TEST PHASE

Assurance personnel shall ensure that the subassemblies, assemblies, components, and contract end-items are integrated and tested in accordance with controlling documents. Articles undergoing test shall not be adjusted, modified, repaired, reworked, or replaced except as specified in established documents, or in accordance with MRB actions. The status, configuration, and integrity of the hardware must be maintained and documented. Integration and test activities shall be conducted in a clean area in accordance with the Contamination Control Plan.

Assurance personnel shall provide surveillance of all tests; the extent shall be defined in QA and test documents by quality assurance management. As a minimum the activities in the following paragraphs shall be performed.

8.15.4.1 Verification. Prior to testing, the assurance personnel shall verify:

a. The presence of approved inspection and test documents.

b. The identification of products.

c. The configuration of products.

d. That test equipment is within the calibration period for the duration of the test.

e. Test setup and test configuration.

8.15.4.2 Test Documentation. During tests the assurance personnel shall:

a. Ensure that tests are conducted in accordance with approved specifications and procedures.

b. Ensure accurate and complete recording of data and results.

c. Document rework, repairs or modifications.

d. Document nonconformances.

8.15.4.3 Post Test Assurance Activity. Subsequent to testing, the assurance personnel shall:

a. Ensure proper disposition of articles.

b. Verify that test results, reports, and nonconformance documents are accurate, complete, and traceable to the

tested products. Any additional nonconformances shall be processed in accordance with 8.13.

8.15.5 RECORDS OF INSPECTIONS AND TESTS (COMPONENT LEVEL TO END-ITEM)

8.15.5.1 General Requirements. The contractor shall prepare and maintain records, including photographs and logs, of all inspections and tests to show that all operations have been performed, the objectives met, and the end-item fully verified.

8.15.5.2 Scope. Records shall cover each component, subsystem, and system. As the hardware is integrated, records of lower-level assembly products shall be combined into those for the end-item as a means of compiling a continuous, chronological history of identified hardware, fabrication, assembly, inspection, and tests as well as other actions or data important to a complete assurance record, such as idle periods (storage), movement of the end-item, repairs, approvals, maintenance, configuration data, etc.

Assurance personnel shall verify that records are complete. The records shall be retained at the contractor's facility for a minimum of five years after launch of the hardware or otherwise as prescribed by the contract.

8.16 CONFIGURATION VERIFICATION

Assurance personnel are required to verify that the as-built product complies with the currently approved as-designed configuration listing and is in accordance with approved configuration documents as required by the Configuration Management Plan and with paragraphs 8.3 and 8.4. The configuration shall be maintained and controlled throughout the program.

Configuration verification is required as a part of all inspections (see par. 8.15.3). A nonconformance report shall be initiated in accordance with par. 8.13 for any deviations of inspected as-built hardware from the current approved configuration. Any configuration nonconformances that are not corrected shall be documented on a Deviation/Waiver request form (see Figure 4-3) and processed in accordance with approved configuration management procedures.

For End-Item Inspections (see par. 8.15.3.3), the contractor shall also provide an as-built configuration verification report for inclusion in the End-Item Data Package. This verification report, based on inspection of the as-built hardware and review of records of lower levels of assembly that are not visually verifiable at the time of end-item inspection, shall list all nonconformances of the as-built hardware and software from the latest approved configuration.

The as-designed configuration and updates, as well as the as-built configuration verification report, shall be provided in accordance

with the Contract configuration management requirements and included in the Acceptance Data Package (see par. 8.23).

8.17 METROLOGY

8.17.1 GENERAL REQUIREMENTS

The contractor shall establish and comply with a documented metrology system that ensures that measurement standards and equipment (including GSE) are selected and controlled to the degree necessary to meet drawing requirements and functional test requirements.
The system shall be in accordance with provisions of MIL-STD-45662 (Appendix A).

8.17.2 INSTRUMENTS USED FOR MEASURING

Tools, gages, jigs, and fixtures which measure dimensions, contours, or locations affecting quality characteristics shall be checked for accuracy prior to use. Also, test equipment and instruments (including GSE) used in functional test of the hardware shall be calibrated to standards appropriate to their test uses and shall be checked for accuracy in accordance with appropriate procedures prior to use. Checks and recalibrations shall be made at predetermined intervals to ensure continued accuracy.

8.17.3 PRODUCT MEASUREMENT PROCESS

The sum of random and systematic errors in any article or material measurement process shall not exceed ten percent of the tolerance or material characteristics being measured. Where state-of-the-art or other considerations make this provision impossible or impracticable the contractor shall maintain a list of exceptions, and they shall be available for review upon request.

8.17.4 CALIBRATION MEASUREMENT PROCESS

The sum of random and systematic errors in any calibration measurement process shall not exceed 25 percent of the tolerance of the parameter being measured. Where state-of-the-art or other considerations make this provision impossible or impracticable the contractor shall maintain a list of those exceptions and they shall be available for review upon request.

8.18 STAMP CONTROL SYSTEM

The contractor shall establish and maintain a documented stamp control system which provides the following:

a. Stamps, decals, seals, and paints which are applied to flight hardware shall comply with the criteria of 6.2.4 and shall show that products have undergone source and receiving inspection, in-process fabrication and inspection, end-item fabrication, inspection and storage, and shipment.

b. Stamps shall be traceable to the certified individual responsible for their use, and records shall be maintained

to identify the individual. Fabrication (manufacturing) and inspection stamps shall be of different design.

c. Stamps shall be applied to records to indicate the fabrication or inspection status of the products.

8.19 SAMPLING PLANS

Sampling plans may be used when inspections or tests are destructive, or when data, inherent characteristics, or the noncritical application of a product allows for a reduction in inspection or testing.
Such plans shall not jeopardize quality, reliability, or design intent. MIL-STD-105 (Appendix A) shall be used for establishing the sampling plan requirements. The sampling plan shall provide an average quality level that is appropriate to the reliability requirements of the project. Sampling plans shall be identified in the applicable inspection procedures, and a listing of those inspection procedures utilizing sampling plans, including the sampling rationale, shall be maintained as a part of the inspection planning documentation (paragraph 8.15.1).

8.20 TRAINING AND CERTIFICATION FOR MANUFACTURING AND INSPECTION PERSONNEL

8.20.1 TRAINING

The contractor shall use trained personnel for implementing the performance assurance program including interpretation of related accept/reject criteria, and processes control. Training programs shall be developed, documented, implemented, and maintained for personnel who may have an effect upon, or who are responsible for reliability and quality.

8.20.2 CERTIFICATION AND RECERTIFICATION OF PERSONNEL

a. Certification- Personnel who perform or inspect processes and operations identified in the handbooks named in 8.10.3 or any additional processes and operations not covered by the handbooks (examples are - soldering, module welding, potting, harness fabrication, encapsulation, and nondestruction evaluations), shall be trained and certified in accordance with the applicable NHB, MIL-STD, or specification.

b. Recertification- Personnel shall be recertified every two years to show continuance of their ability to fabricate and inspect hardware. In addition, they shall be recertified if they fail to perform satisfactorily, or because of changes in techniques or required skills, or by the interruption of work experience as established for the process or operation. Recertification shall require retesting of the individual to demonstrate proficiency. Persons failing the retest shall

not perform the tasks until they receive additional training and proficiency has been demonstrated.

8.20.3 RECORDS

Records shall be maintained of the training, testing, certification, and recertification status of personnel.

8.21 HANDLING, STORAGE, PRESERVATION, MARKING, LABELING, PACKAGING, PACKING, AND SHIPPING

The contractor shall prepare and implement procedures for the handling, storage, preservation, marking, labeling, packaging, packing, and shipping of all products. Procedures shall be submitted in accordance with GSFC-422-12-12-04 (CDRL). The procedures shall implement the requirements of NHB 6000.1 (Appendix A) and the following paragraphs.

8.21.1 HANDLING

The protection of products during the life of the program shall be achieved through the use of handling equipment (including GSE) and techniques which have been certified before use. Evidence of initial and periodic proof-testing of handling equipment shall be maintained.

8.21.2 STORING, PRESERVATION, MARKING, LABELING PACKAGING, AND PACKING

Products shall be stored, preserved, marked, labeled, packaged, and packed to prevent loss of marking, deterioration, contamination, or damage during all phases of the program. Stored and stocked items shall be controlled in accordance with documented procedures and be subject to quality surveillance as stated in paragraph 8.15.3.4.

8.21.3 SHIPPING

For instruments that are sensitive to damage from mechanical shock or extreme temperature exposure, monitoring devices shall be included at appropriate locations within the shipping containers to provide evidence of any exposure to potentially damaging shipping stresses.

Prior to shipping, quality assurance personnel shall ensure that:

a. Fabrication, inspection, and test operations have been completed and accepted.

b. All products are identified and marked in accordance with requirements.

c. The accompanying documentation (contractor's shipping and property accountable form) has been reviewed for completeness, identification, and quality approvals.

d. Evidence exists that preservation and packaging are in compliance with requirements.

e. Packaging and marking of products, as a minimum comply with Interstate Commerce Commission rules and regulations and are adequate to ensure safe arrival and ready identification at their destinations.

f. The loading and transporting methods are in compliance with those designated in the shipping documents.

g. Integrity seals are on shipping containers and externally observable shock or temperature monitors do not show excessive environmental exposure.

h. In the event of unscheduled removal of a product from its container, the extent of reinspection and retest shall be as authorized by NASA or its representative.

i. Special handling instructions for receiving activities, including observation and recording requirements for shipping- environment monitors, are provided where appropriate.

The contractor's quality assurance organization shall verify prior to shipment that the above requirements have been met. QA shall sign off appropriate shipping documents to provide evidence of this verification.

8.22 GOVERNMENT PROPERTY CONTROL

8.22.1 CONTRACTOR'S RESPONSIBILITY

In accordance with the provisions of the contract, the contractor shall be responsible for and account for all property supplied by the Government including Government property that may be in the possession or control of a supplier. The contractor's responsibility shall include, but not be limited to, the following:

a. Upon receipt, examine products to detect damage that may have occurred in transit.

b. Inspection for quantity, completeness, proper type, size and grade as specified in the shipping documents.

c. Provision for the protection, maintenance, calibration, periodic inspection, segregation, and controls necessary to

prevent damage or deterioration during handling, storage, installation, or shipment.

d. Maintenance of records which include:

(1) Identification of the property.

(2) Location of the property.

(3) Dates, types, and results of contractor inspections, tests, and other significant events.

e. Any functional tests shall be performed on the product only if such tests are directed by the NASA project office.

8.22.2 UNSUITABLE GOVERNMENT PROPERTY

The property shall be processed in accordance with Government procedures and 8.13. The property shall not be dispositioned, repaired, reworked, replaced, or in any way modified unless such action is authorized by the contract or by the Contracting Officer in writing.

8.23 GOVERNMENT ACCEPTANCE

Prior to acceptance by NASA, quality assurance personnel shall ensure that deliverable contract end-items, including the Acceptance Data Package, are in accordance with contract requirements. A copy of the data package shall be submitted to NASA in accordance with GSFC-422-12-12-04 (CDRL) and a copy shall accompany each end-item.

SECTION 9

CONTAMINATION CONTROL REQUIREMENTS

9.1 APPLICABILITY AND DEFINITIONS

A contamination control program shall be conducted. Contamination control allowances shall be used to establish the contamination control requirements for the integration, test, and mission use of the instrument when integrated with the spacecraft.

Contaminants are defined as those materials, either at a molecular or a particulate level, whose presence degrades mission performance. The source of these contaminants may be the spacecraft, the instrument, other instruments in the payload, any material or equipment coming in contact with the instrument, the test facilities, and/or the environments to which the instrument is exposed.

9.2 CONTAMINATION CONTROL PLAN

The contractor shall prepare and implement a Contamination Control Plan (CCP) that includes contamination allowances, methods for control, and verifications that the allowances have been met. At least one copy of all referenced analyses, procedures, standards, and specifications, with the exception of Government standards, shall be provided with the CCP. The plan shall be submitted in accordance with GSFC-422-12-12-04 (CDRL).

9.2.1 CONTAMINATION ALLOWANCES

As a basis for contamination control activities, the contractor shall establish contamination allowances for performance degradation of contamination-sensitive hardware such that, even when degraded by contamination within the stated allowance, the hardware will meet its mission objectives. The contamination allowances for the contractor's instrument shall reflect the allowable contamination levels defined in par. 9.3, below. The following information related to contamination allowances shall be included in the CCP:

-- The sensitivity of the instrument to contamination, the contamination control concerns, and potential sources of contamination;

-- The science requirements and allowable performance degradation;

-- Contamination allowances for all sensitive surfaces. These allowances are derived from the allowable performance degradation, and shall be stated as surface cleanliness levels (molecular and particulate) in accordance with MIL-STD-1246 or

equivalent (see Tables 9-1 and 9-2). Allowable outgassing and particulate contamination levels shall also be defined for materials or subsystems near contamination-sensitive surfaces.

All analyses performed to assess instrument sensitivity and to derive contamination allowances shall be documented.

9.2.2 CONTAMINATION CONTROL

The contractor shall prescribe in the CCP the measures to be taken to ensure that the contamination allowances established under 9.2.1 are not exceeded. This shall include a description of the facilities, and a description of all procedures used after fabrication and during integration and test, interfacing with other subsystems or the spacecraft, cleaning, bagging, transportation, etc. An operations flow chart shall be included.

It is required that the total amount of outgassed condensable volatile matter from the instrument stay within the outgassing and particulate contamination allowances in section 9.2.1, even though the construction materials used satisfy the unit outgassing criteria for TML and CVCM prescribed in section 6.2.4.

The contractor shall detail in the CCP the methods of verification (e.g. measurements, inspections, tests, and analyses) to be used during each phase of the hardware lifetime. For each method, the documented procedure and data recording requirements must be enumerated or referenced. The CCP shall include criteria for defining out-of-control conditions and planned methods of dealing with them.
(See Appendix C for additional EOS requirements).

9.2.3 BAKE-OUTS

Bake-outs of wiring harnesses and thermal blankets are required since past experience has shown these to be major contributors to the contamination level of hardware in test and flight. For highly contamination-sensitive instruments, bake-outs of critical subsystems before final instrument assembly may also be necessary. During these bake-outs, the outgassing must be measured to ensure compliance with the allowances in 9.2.1. The parameters (e.g. verification method, temperature, duration, pressure) of such bake-outs must be individualized, depending on the materials used, the fabrication environment, and the established contamination allowance.

Table 9-1
EQUIVALENT WAYS TO EXPRESS
PARTICULATE CONTAMINATION ON SURFACES

MIL-STD-1246B Level	# of particles/cm2	*Percent Obscuration **
300	1	0.02
300	4	0.09
500	13	0.3
600	30	0.7
700	70	1.6
750	100	2.2
800	150	3.3
900	275	6.0

* This is number of particles visible on the surface when inspected with high intensity white light from a distance of 10 to 30 cm (6 to 12 inches). Only particles of size 50 microns or larger are assumed to be visible.

** This is the percentage of surface area obscured by particles.

Table 9-2
EQUIVALENT WAYS TO EXPRESS
MOLECULAR CONTAMINATION ON SURFACES

MIL-STD-1246B Level	Max. mass deposition (µg/cm2)	Max. layer thickness (nm) *
A	1	10
B	2	20
C	3	30
D	4	40

* Assuming the molecular contamination has an average density of 1g/cm3.

The bake-out parameters for each hardware item shall be documented in individual bake-out specifications and referenced in the CCP.

9.2.4 THERMAL VACUUM TEST

The Contamination Control Plan shall include or reference the contamination controls to be exercised in preparing the thermal-vacuum chamber and the necessary fixtures and stimuli for system level tests. These shall include the operational procedures that will be followed to minimize the potential contamination hazard, from pumpdown through return to ambient conditions. Test phases that represent contamination hazards and the approaches to be taken to minimize these hazards shall be addressed. Pretest measurements, monitoring methods to be used during the test, and post-test measurements for verifying that contamination criteria have not been exceeded shall be prescribed. Contingency plans dealing with the possibility that contamination criteria are exceeded shall be included.

9.3 INSTRUMENT CROSS-CONTAMINATION

EOS Only. See Appendix C, EOS Unique Requirements.

SECTION 10

SOFTWARE ASSURANCE REQUIREMENTS

10.1 GENERAL REQUIREMENTS

The contractor shall establish an organized program of software assurance for all new or modified software that includes verification and validation, quality assurance, configuration management, and nonconformance reporting and corrective action. This software assurance program shall be coordinated with the hardware and system oriented assurance program established. The software assurance program shall encompass flight software and firmware, ground support equipment software, and any software purchased or developed under this contract that is related to flight mission operations.

10.1.1 DOCUMENTATION

In preparing software, the contractor shall describe the software management and assurance approach that will be followed in developing and verifying new software. A list of the documentation to be produced for the software elements covered by this assurance requirement shall be supplied.

The effectivity relationship of the issuance of versions of this documentation to configuration management baselines required in section 10.4 shall be documented.

10.2 VERIFICATION AND VALIDATION

The contractor shall plan and implement a verification and validation process to demonstrate that new software is correct and meets its requirements. It shall include testing, walkthroughs or inspections, and reviews.

10.2.1 SOFTWARE TEST PLAN

The contractor shall develop and submit in accordance with GSFC-422-12-12-04 (CDRL) a software test plan for each major software component covered by this assurance requirement. The plan shall show the requirement driven software acceptance tests and any hardware/software integration tests that will be done to demonstrate that the software component meets its requirements. The plan shall include the tests that will be used to demonstrate that each software requirement has been satisfied, the environment under which the test is to be conducted, the data required for the test, the expected results, test schedules, and any special operating conditions required. It is to be updated as requirements are updated and be included as part of each review required in section 10.2.5. This plan shall also describe any special test support tools (i.e., simulators, emulators, etc.) needed for the testing

and any required support from other organizations to perform the testing.

After acceptance of any version of the software, any changes to the baselined version of the software shall require issuance of a new or revised test plan in accordance with the requirements of the Project configuration management system. If the software is updated, regression testing is required and shall be so identified in the test plan.

10.2.2 SOFTWARE TEST PROCEDURES

The contractor shall prepare software test procedures that implement the software test plans required in 10.2.1.

10.2.3 SOFTWARE TEST REPORTS

The contractor shall prepare a software test report(s) that summarizes each of the software acceptance testing and/or retesting activities. The report shall show which of the planned tests were completed, conformance of the test results to the expected results, the number, type and criticality of the discrepancies found, the identification of components tested, and an analysis of any performance requirements that the items tested could affect. The actual test results shall either be attached to the report(s) or maintained available. Test reports shall be provided in accordance with GSFC-422-12-12-04 (CDRL).

10.2.4 SOFTWARE WALKTHROUGHS OR INSPECTIONS

The contractor shall conduct walkthroughs or inspections on requirements, detailed design and code. The team doing the walkthrough shall include individuals not responsible for the development of the design or code being reviewed and a software QA member. NASA personnel will not normally participate in contractor walkthroughs. However, in special cases, at the request of the NASA FAM, the contractor shall make provision for inclusion of designated NASA personnel in specific, identified walkthroughs. The walkthrough process shall be devised with the intent of finding errors or omissions in the design or code. At the contractor's option, the process may be used to enforce design and coding standards.

10.2.5 SOFTWARE REVIEWS

The software review process shall include both internal reviews and external reviews.

The contractor shall support three external GSFC conducted software reviews in addition to the Flight Assurance Reviews described in section 2.0 of this document: (1) a Software Requirements Review (SWRR) (the requirements shall be baselined prior to the early design effort), (2) a PDR and (3) a CDR. The reviews shall address the following:

a. The Requirements Review shall address the definition of the software requirements relative to the system-level requirements for each software-hardware system within the

instrument and the interfaces of these systems with the spacecraft. This review shall also formally define the interface boundaries between the software and hardware in each internal software-hardware system. This Review shall include a preliminary version of the Software Test Plan which describes the major tests to be performed to demonstrate that the requirements are satisfied.

b. The Preliminary Design Review shall present the software requirements, an architectural level design description, and a requirements driven test approach.

c. The Critical Design Review shall describe the software detailed design, including the data flow and the interfaces, and an implementation approach/plan.

d. At each review, any questions or issues relating to the potential impact of the software on system safety shall be addressed.

e. Software review material shall address questions of data security, including protection of software products from unauthorized access and modifications, as well as protection against loss from natural sources or operational anomalies.

10.3 SOFTWARE QUALITY ASSURANCE

10.3.1 STANDARDS

The contractor shall establish standards for software and project documentation, including the documentation of software designs and interface specifications. Unless otherwise approved by the Contracting Officer, the contractor shall use the NASA software documentation standards contained in the "Information System Life-Cycle and Documentation Standards" (Appendix A).

The contractor shall also set standards for code and for the internal, code level documentation.

10.3.2 ASSURANCE FUNCTION

The contractor shall have an assurance function which verifies that the standards required by section 10.3.1 have been met. The assurance function shall also verify that the required test, configuration management, and nonconformance reporting procedures have been followed, and that walkthroughs are completed. The software assurance function shall be a part of the over-all Project performance assurance system established in accordance with this document.

10.4 SOFTWARE CONFIGURATION MANAGEMENT

The contractor shall establish a software configuration management process to manage requirements, design, code, data, and documentation, and to track and report on the status of changes to them.
The software configuration management system shall be a part of or shall be conducted in close coordination with the over-all Project configuration management system. This software configuration management process shall include, as a minimum, the following elements:

a. Identification of configuration items that will be baselined and maintained under configuration control. The contractor shall establish at least three baselines, one after each of the formal software reviews required in section 10.2.5 and one after the acceptance test has been conducted and the software accepted for use.

b. A change classification and impact assessment process. The process must result in Class 1 software changes being forwarded to GSFC for disposition. Class 1 software changes are defined as those which affect system requirements, software requirements, system safety, reliability, cost, schedule, and external interfaces.

c. A Configuration Control Board (CCB) that reviews and dispositions changes.

d. Version control and media labelling methods and procedures.

e. A media control process. The contractor shall state the methods and facilities to be used to protect computer program physical media from unauthorized access or inadvertent damage or degradation.

The contractor shall establish procedures that detail the steps to accomplish the CM process, including any needed forms and their processing.

10.5 SOFTWARE NONCONFORMANCE REPORTING AND CORRECTIVE ACTION

The contractor shall establish a process for the reporting, analysis, correction, and verifying effectiveness of correction of nonconformances discovered in the software and software documentation during the development of the software. After development and starting with the first use of a software item with the flight hardware, software nonconformances shall be reported and dispositioned through the Problem/Failure reporting (PFR) system (section 8.13.2). Provision shall be made for transfer of nonconformance data from the development phase reporting activity including software acceptance tests, to the PFR system on any nonconformances which, in the judgement of the

cognizant development activity, may be of value in analyzing later potential problems.

Data on any problems occurring during the succeeding tests of the software with the mission hardware shall be entered in the PFR system. Software nonconformance reports and software test failure reports prior to integration with the mission hardware shall be available at the contractor's facility for Government review.

The nonconformance reporting and corrective action process at all times shall interface with the software configuration management process such that change control is effected, and that reported nonconformances and change requests are so identified and processed. The contractor shall maintain a reporting process that shows the status and criticality of all nonconformances.

The contractor shall document procedures that detail the steps to accomplish the nonconformance reporting and corrective action process. These shall be submitted for NASA review in accordance with GSFC-422-12-12-04 (CDRL).